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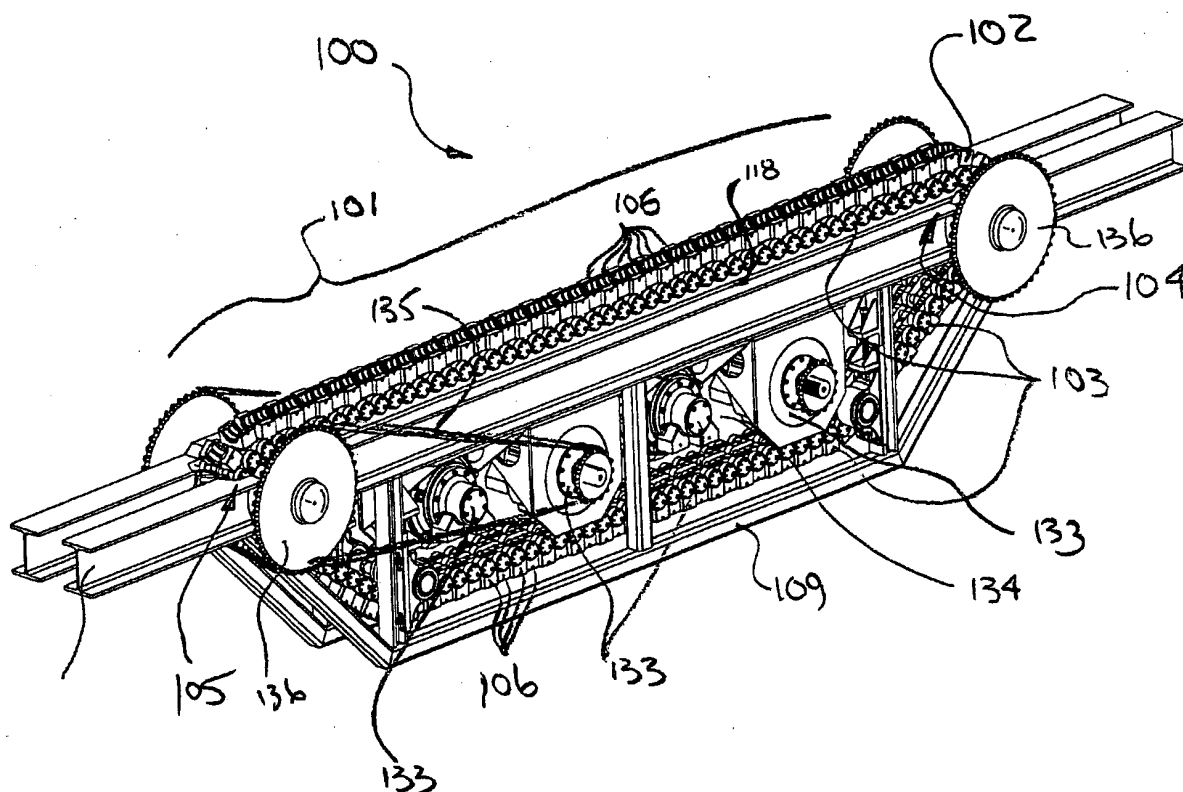
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(54) Titre : INJECTEUR LINEAIRE DE TUYAUX EN SPIRALES  
(54) Title: LINEAR COILED TUBING INJECTOR



(57) Abrégé/Abstract:

An injector is provided for injecting and withdrawing large diameter coiled tubing comprising a linear section of gripping blocks driven on an endless chain conveyor. The coiled tubing is forced into frictional engagement with the blocks by a corresponding linear array of rollers. The arrangement is gentle on the coiled tubing. The injector is not restricted in length and thus provides a linear driving section of configurable length for providing superior injection and pulling capacities. In combination with the strong draw works, mast and rotary table of a conventional rig enabling making up both sectional tubing for assembling BHA's, drilling surface hole and making up to non-rotating coiled tubing from the injector.

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(DOCUMENT AU 10 IÈME ÉTAGE AIRE 5 DANS LA SECTION DE LA  
PRÉPARATION DES DOSSIERS)

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# "LINEAR COILED TUBING INJECTOR"

## FIELD OF THE INVENTION

The invention relates to coiled tubing injectors, and apparatus and methods for combining conventional sectional tubing drilling with drilling using coiled tubing. More particularly, a collapsible mast and a rotary table can be arranged for operation with both a catwalk for sectional tubulars and with a coiled tubing unit. A linear coiled tubing injector is sufficiently narrow to coexist in the mast while tripping conventional tubulars.

## BACKGROUND OF THE INVENTION

The general background relating to coiled tubing injector units is described in U.S. Patent No. 5,839,514 and 4,673,035 to Gipson which are incorporated herein by reference for all purposes.

Apparatus for conventional drilling with sectional tubing is very well known.

Coiled tubing has been a useful apparatus in oil field operations due to the speed at which a tool can be run in (injected) and tripped out (withdrawn) from a well bore. Coiled tubing is supplied on a spool. An injector at the wellhead is used to grip and control the tubing for controlled injection and withdrawal at the well. As coil tubing cannot be rotated, drilling with coiled tubing is accomplished with downhole motors driven by fluid pumped downhole from the surface.

The use of coiled tubing has advantages over conventional drilling due to the potential to significantly speed drilling and reduce drilling costs

1 through the use of continuous tubing. The most significant cost saving factors  
2 include the reduced pipe handling time, reduced pipe joint mak up time, and  
3 reduced leakage risks.

4 Exclusive use of coiled tubing is associated with several limitations.  
5 Certain stages of drilling operations still require making up of threaded joints, the  
6 means for which are not typically provided with coiled tubing rigs. Further, a  
7 coiled tubing injector has limited pulling strength as compared to the draw works  
8 provided with conventional sectional tubing masts. Further, a conventional  
9 wellhead injector tends to inject tubing which has a residual bend therein.  
10 Residual bend results in added contact and unnecessary forces on the walls of  
11 the drilled hole or casing, increasing frictional drag and causing an offset  
12 positioning of the tubing within the hole. Occasionally the coiled tubing can wad  
13 up in the hole (like pushing a resilient rope through a tube) and cannot be  
14 injected any further downhole or ever actually reach total depth.

15 As described in US Patent 5,842,530 to Smith et al. (Smith),  
16 apparatus is disclosed which is directed to providing a single rig having both  
17 conventional and coiled tubing capability. Smith describes how sectional tubing  
18 is used during the vertical, and substantially linear, drilling and switching to non-  
19 rotation tubing and downhole motors after deviating the well to the horizontal.  
20 However, by combining the two technologies in a single rig, Smith's mast is  
21 limited in its crown and draw works capacity. Further, Smith discloses the use of  
22 a conventional injector.

23 A conventional injector comprises two continuous, parallel and  
24 opposing conveyors having grooved shoes or blocks mounted thereon such as  
25 that disclosed in US Patent 5,533,668 to Council et al. for Halliburton Company,

1 Oklahoma. The opposing conveyors have facing portions where the multiplicity  
2 of gripping blocks run parallel for gripping the tubing therebetween, typically  
3 positioned inline, directly adjacent and above the wellhead.

4 One characteristic of the dual conveyor injectors is that the facing  
5 grooved blocks must have absolutely synchronous timing and engagement with  
6 the coiled tubing, the failure to do so being associated with damage to the coiled  
7 tubing. Damage to the coiled tubing further reduces the lifespan of tubing  
8 already suffering a short lifespan due to reversing stresses inherent in the  
9 technique.

10 In US Patent 5,839,514 to Gipson, an improved injector comprises  
11 a grooved reel and hold-down rollers for imparting the gripping force necessary  
12 to drive the coiled tubing. This reel type injector, while causing less damage to  
13 the tubing than the block type is limited in pull capability, in part due to the short  
14 tubing gripping length. The gripping length of reel-type coiled tubing drives is  
15 limited by the circumference of the reel; the maximum circumference being  
16 limited to less than 360 degrees due to the inability to permit overlap tubing  
17 wrapped around a grooved driving reel.

18 Deeper wells can be accessed, for either workover or drilling  
19 purposes if the pull strength can be increased. Further, deeper wells usually  
20 require larger diameter tubing to handle greater string weight and to minimize  
21 fluid pumping power requirements. As the fluid for driving mud motors is  
22 delivered down the bore of tubing, fluid friction causes significant pressure drop  
23 and thus require large power sources at the pumps. The larger the tubing, the  
24 lower the fluid friction losses and the lower the power requirements.

1           Rigs utilizing either the dual conveyor or the reel type injectors  
2 have had difficulty in dealing with larger diameter tubing. Further, while the use  
3 of coiled tubing has enabled faster operation to depth and out again, the  
4 equipment has a higher capital and operating cost. For example, coiled tubing  
5 rigs use more complicated and expensive equipment, have higher power  
6 requirements for overcoming fluid friction losses and the repeatedly deformed  
7 coiled tubing has a limited life which requires periodic replacement with new  
8 coiled tubing.

9           Further, coiled tubing apparatus is typically provided on a single  
10 transportable rig which provides a spool of coiled tubing, an injector and its own  
11 mast which is designed for light or small diameter coiled tubing, portability and  
12 generally low pull weight. In summary, the mast and rigs generally are not  
13 suitable for work with deeper wells.

14

## SUMMARY OF THE INVENTION

### Linear Injector

In one aspect the linear injector of the present invention extends coiled tubing capability beyond that known heretofore. In combination with a conventional jointed drilling rig, none of the functionality of the conventional rig is sacrificed while achieving enhanced capabilities by the addition of coiled tubing.

In the preferred embodiment, coiled tubing is driven along a linear section of an endless chain conveyor with an opposing linear array of rollers. Using prior art dual conveyors, gripper blocks pull on both sides of the coiled tubing and the present invention only pulls on one side. Applicant has found that by eliminating the prior art parallel chain drives, the difficulty to synchronize the two drives is avoided and the substitution of non-driving rollers for one side of the tubing injector results in less damage to the coiled tubing. Further, by eliminating the challenge of maintaining dual chain synchronicity, the novel injector is able to take unrestricted advantage of an extended length of a linear driving section, thus providing superior injection and pulling capability.

Accordingly, in one preferred aspect of the invention, deep wells can be drilled with coiled tubing even from the surface due to the combination of enabling the use of full diameter tubing, implementing a straightener and using an injector which is capable of applying both significant injector force on a drilling bit and full pulling capability for tripping out of the deep wells. An injector of 20 feet in length is capable of a nominal pulling capacity of about 100,000 lb. force. Further, suspension of the preferred injector in a conventional derrick having strong draw works and a rotary table permits operation with both conventional sectional tubing, including BHA, and simplifying the making up to coiled tubing.

1           In a broad aspect of the invention then, coiled tubing injection  
2 apparatus is provided comprising:

- 3           • a chain conveyor extending about an endless path and having  
4           at least one linear section aligned with the wellbore;
- 5           • a multiplicity of gripper blocks conveyed and driven by the chain  
6           conveyor, the gripper blocks forming a substantially continuous  
7           coiled tubing support while traversing the linear portion;
- 8           • a linear array of a multiplicity of rollers in parallel and opposing  
9           arrangement to the linear section of the chain conveyor for  
10          forming a corridor therebetween and through which the coiled  
11          tubing extends, the rollers urging the coiled tubing into frictional  
12          engagement with the gripper blocks;
- 13          • means for supporting the gripper blocks against the normal  
14          forces produced by the linear array of rollers; and
- 15          • means for driving the chain conveyor along the endless path so  
16          as to drive the gripper blocks which frictionally drive the coiled  
17          tubing along the corridor.

18           Preferably idlers extend laterally from the gripper blocks for rolling  
19 along a track, thereby supporting the normal forces on the chain conveyor. More  
20 preferably, biasing means are provided for adjusting the normal force imposed  
21 by the rollers against the coiled tubing. Further, a tubing straightener is  
22 positioned between the apparatus and a source of coiled tubing, just preceding  
23 the corridor between the linear portion of the gripper blocks and the linear array  
24 of rollers.



1           In another embodiment, the linear injector can be pivotally mounted  
2 to a mobile transport for aligning the linear injector with wellheads at any angl to  
3 the surface.

4           In another aspect, the present invention utilizes a combination of  
5 apparatus which borrows the best of both the conventional and coiled tubing  
6 drilling apparatus for providing improved efficiency in drilling operations. Both  
7 the conventional and coiled tubing art is improved to permit even deep wells to  
8 be drilled using coiled tubing. While conventional coiled tubing injectors could be  
9 used, they must be narrow enough to standby in the mast while sectional drilling  
10 is ongoing. One such injector is a novel coiled tubing linear injector which further  
11 extends coiled tubing capability beyond that known heretofore. When used in  
12 combination with a mast capable of handling conventional tubing, none of the  
13 functionality of the conventional rig is sacrificed while achieving enhanced  
14 capabilities by the addition of coiled tubing. Where it would normally be required  
15 to use a very tall mast for making up stands of sectional pipe, a shorter mast can  
16 be implemented with coiled tubing. Further, by providing a mast which is  
17 accessible on two sides, and having a side-shifting crown assembly with dual  
18 block/hooks combinations, then operations with both conventional sectional and  
19 coiled tubing is radically simplified and streamlined.

1           In a preferred embodiment, two rigs are provided. A first rig  
2 comprises a collapsible mast on a trailer, a substructure, rotary tubing drive  
3 means (table or power swivel), side shifting crown, dual blocks and dual  
4 drawworks. An integrated hydraulic system powers the drawworks, side-shifting  
5 crown, rotary table and lifts the collapsible mast. A second rig comprises a  
6 coiled tubing injector and a reel of coiled tubing on a trailer. Suitable support  
7 equipment is provided such as a mud system, mud pump and control house.  
8 The two rigs are arranged tail to tail. The mast, when erected, has a first side  
9 open to the deck of the trailer of the first rig, forming a catwalk for drill pipe. The  
10 opposing side of the mast is open to the second coiled tubing rig. Accordingly,  
11 lengths of sectional tubulars can be handled or drawn up the first open side from  
12 the first rig; and coiled tubing can be introduced from the second side.

13           While other injectors of mast-capable installation are anticipated, in  
14 the most preferred embodiment, the novel injector meets all the requirements,  
15 having a shallow depth and can idle, set aside in the mast, when handling  
16 sectional tubulars (tubing or casing). Simply, the preferred injector comprises a  
17 linear section of an endless chain conveyor with an opposing linear array of  
18 tubing hold-down rollers. As disclosed above, by eliminating the prior art dual  
19 and parallel chain drives it is possible to eliminate the known difficulty of  
20 synchronizing the two drives and to avoid the bulky machinery of dual chain  
21 drives required to hold the dual drives in facing relation. Further, the  
22 substitution of non-driving rollers for one side of the tubing injector results in less  
23 damage to the coiled tubing. Further, by eliminating the challenge of maintaining  
24 dual chain synchronicity, the novel injector is able to take unrestricted advantage

1 of an extended length of a linear driving section, thus providing superior injection  
2 and pulling capability and enabling of conventional diameter tubing.

3 Accordingly, in one preferred aspect of the invention, deep wells  
4<sup>x</sup> can now be drilled with coiled tubing, even from the surface, due to the  
5 implementation of an injector which is capable of applying both significant  
6 injector force on a drilling bit and full pulling capability for tripping out of the deep  
7 wells, and preferably a straightener and even being able to using conventional  
8 diameters of sectional tubulars. It is noted that the novel injector is capable of 15  
9 feet in length is capable of a nominal pulling capacity of about 80,000 lb. force.  
10 Further, suspension of the preferred injector in a mast, having both strong draw  
11 works and a rotary table, permits operation with both conventional sectional  
12 tubing, including assembling of the BHA, and simplifying the making up to coiled  
13 tubing. Having both open sides minimizes the footprint of this hybrid drilling  
14 apparatus. Further drilling efficiency is improved, eliminating wasted steps  
15 formerly required to decommission one type of drilling apparatus and  
16 commission the other.

17 In a broad aspect of the invention then, a method for hybrid drilling  
18 of a well with both sectional tubulars and coiled tubing comprises the steps of:

- 19 • providing a hybrid drilling system having a mast having at least  
20 one open side and equipped for drilling with tubulars, at least  
21 one drawworks and a drive for rotating tubulars, and having a  
22 coiled tubing injector having a supply of coiled tubing;  
23 • lifting the injector into the mast using the drawworks;  
24 • alternately drilling with tubulars or with coiled tubing; and  
25 • setting the injector aside in the mast when drilling with tubulars.

1                    Preferably, the method further comprises handling tubulars and  
2 coiled tubing through the same open side of the mast. More preferably, the  
3 tubulars and are handled through separate open sides of the mast.

4                    In a broad aspect, apparatus for achieving the above method  
5 comprises:

- 6                    • a mast over the well having at least one open side;
- 7                    • drawworks and a rotary drive for the handing and drilling of the  
8 tubulars through the mast's open side; and
- 9                    • a coiled tubing injector and supply of coiled tubing, the injector  
10 being sufficiently compact to be hung in the mast from the  
11 drawworks with the coiled tubing being supplied through the  
12 mast's open side.

13                    Preferably, the apparatus comprises a mast and tubular rotating  
14 means, the mast having a side shifting crown having at least two positions over  
15 the well and first and second opposing and open sides, a first block/hook fitted to  
16 the side shifting crown and being fitted with elevators for handling tubing through  
17 the first open side; a second block/hook being fitted to the side shifting crown,  
18 the second block hook being alternately fitted with, a swivel for rotary drilling with  
19 tubulars, and a coiled tubing injector for drilling with coiled tubing supplied  
20 through the second open side; and a coiled tubing injector, preferably one having  
21 a bi-directional driven chain fitted with tubing gripper blocks which extend about  
22 an endless path and having at least one linear supported section aligned with the  
23 wellbore, and a linear array of hold-down rollers in parallel and opposing  
24 arrangement to the linear section of the chain conveyor for forming a corridor

1 therebetween and through which coiled tubing extends, the rollers urging the  
2 coiled tubing into frictional engagement with the gripper blocks.

3

4 BRIEF DESCRIPTION OF THE DRAWINGS

5 Linear Injector

6 Figure 1 is a perspective view of a linear coiled tubing injector  
7 according to one embodiment of the present invention; the holddown roller being  
8 removed for illustrating the tubing corridor;

9 Figure 2 is a close up perspective and partial view of the linear  
10 injector of Fig. 1, illustrating tubing being driven between the gripper blocks and  
11 the holddown rollers;

12 Figure 3 is a perspective view according to Fig. 1 illustrating the  
13 array of holddown rollers. The continuous chain and drives are shown removed;

14 Figure 4 is an axial view of the head pulley and cross-section  
15 through the tubing, illustrating a holddown strut;

16 Figure 5 is a side view of the linear injector having a tubing  
17 straightener atop the injector;

18 Figure 6 is a close up, partial side view of the linear injector  
19 according to Fig. 5;

20 Figure 7 is a perspective view of a matched pair of roller gripper  
21 blocks, the wider block being fitted with roller idlers, and one block assembly cap  
22 screw shown exploded from the assembly;

23 Figure 8 is a perspective view of a pair of holddown roller in a  
24 rocker housing;

25 Figure 9 is a perspective view of a belleville spring-equipped strut;

1                   Figure 10 is a cross-section of the strut of Fig. 9;

2                   Figure 11 is a side view of a pull test apparatus, utilizing four  
3 gripper blocks, four corresponding holddown rollers and a hydraulic cylinder, all  
4 according to the Example;

5

6   Single Side Hybrid System

7                   Figure 12 is a side elevation view of one arrangement of the novel  
8 hybrid linear injector in combination with a conventional sectional tubing mast  
9 and draw works with sectional and coiled tubing accessing the mast from the  
10 same open side;

11                  Figure 13 is a plan view of the arrangement according to Fig. 12  
12 illustrating a preferred "V" arrangement of the coiled tubing transport rig, catwalk  
13 and the conventional mast;

14                  Figure 14 is a side elevation view of the linear injector arrangement  
15 according to Fig. 12, the linear injector being in a shipping position on its coiled  
16 tubing trailer;

17                  Figure 15 is a linear injector arrangement according to Fig. 12, the  
18 lower end of the linear injector being pinned in the base of a conventional mast  
19 and the upper end being in a partially raised position as it is being lifted by the  
20 mast's drawworks;

21                  Figure 16 is a close up side view of the linear injector of Fig. 12  
22 installed in the conventional mast and aligned over the wellhead;

23                  Figure 17 is a partial close up of the upper end of the linear injector  
24 of Fig. 16 illustrating the straightener and nip of the blocks and the rollers;

1           Figure 18 is a plan, cross-sectional view of one embodiment of the  
2 head sprocket and drive for illustrating a hydraulic arrangement for loading the  
3 coiled tubing holddown rollers;

4           Figures 19a – 19c illustrate isometric, side and end views  
5 respectively of one embodiment of the gripper block assembly, wherein  
6 conventional roller chain is fitted with brackets and gripper blocks;

7           Figure 20 is an isometric view of an alternate embodiment of  
8 gripper block, specifically illustrating a single offset roller gripper block;

9           Figure 21 is an isometric view of a train of offset roller gripper  
10 blocks according to Fig. 20, one of which is shown fitted with a reaction idler;

11           Figure 22 is an isometric view of an alternate embodiment of a  
12 gripper block, specifically illustrating the narrow block of a matched pair of  
13 narrow and wide roller gripper blocks;

14           Figure 23 is an isometric view of the wider second block of a  
15 matched pair of roller gripper blocks according to Fig. 22;

16           Figure 24 is an isometric view of the wider second block of Fig. 23,  
17 fitted with idlers;

18           Figure 25 is an isometric view of a train of roller gripper blocks  
19 according to Figs. 22 and 23 extending over a sprocket; and

20           Figure 26 illustrates a side elevation view of an alternate  
21 implementation of the novel linear injector, illustrating three stages (a),(b),(c) of  
22 an all-in-one coiled tubing rig utilizing the novel injector for workovers or for  
23 directional drilling of predominately shallow wells;

24

1    Dual Duty Hybrid System

2                   Figure 27 is a side elevation view of one arrangement of a second  
3   embodiment of the hybrid conventional sectional and coiled tubing rig of the  
4   present invention. Sectional tubing is worked from the left open side and coiled  
5   tubing from the right open side through a dual duty mast;

6                   Figure 28 is a side elevation view of a sectional tubing trailer  
7   according to Fig. 27, the dual duty mast being in a shipping position on its trailer;

8                   Figure 29 is a side elevation view of a coiled tubing injector and  
9   reel according to Fig. 28, the injector being stored in a shipping position on its  
10   coiled tubing trailer;

11                  Figure 30a is a side elevation view of the sectional tubing trailer,  
12   with the mast erected, and with the crown positioned for drilling with a kelly,  
13   swivel and sectional tubing;

14                  Figure 30b is an end elevation view of the mast of Fig. 30a, with  
15   the crown shifted for drilling with the kelly aligned with the wellbore;

16                  Figure 31a is a side elevation view of the mast with the crown  
17   shifted for installing the linear injector and initiating feeding of the coiled tubing;

18                  Figure 31b is an end elevation view of the mast of Fig. 31a, with  
19   the crown positioned with the elevators set aside;

20                  Figure 32 is a close up side view of a compact linear injector, ideal  
21   for implementation in hybrid arrangements described herein;

22                  Figure 33a is a side elevation view of the mast with the crown  
23   shifted for landing the linear injector positioned in the mast and with coiled tubing  
24   poised to rest in the guide arch;



1                    Figure 33b is an end elevation view of the mast of Fig. 33a, with  
2    th crown positioned for manipulating the linear injector;

3                    Figure 34 is a side elevation view of the mast of Fig. 33a with the  
4    linear injector lowered and pinned in the mast for coiled tubing drilling;

5                    Figure 35a is a side elevation view of the mast with the crown  
6    shifted for setting the linear injector aside and for aligning the elevators for  
7    running in tubing or casing; and

8                    Figure 35b is an end elevation view of the mast of Fig. 35a, with  
9    the crown shifted so that the elevators are aligned for running tubing or casing.  
10

1           DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

2    Linear Injector

3           Two embodiments of a novel injector are described herein. Figs. 1  
4    – 10 illustrate a particularly compact embodiment of an injector 100. Figs. 16 –  
5    18 illustrate a second injector embodiment 200, the variance between the two  
6    being characterized primarily in the packaging of the drives, the overall length of  
7    the coiled tubing gripping section, and the type of tubing holddowns. Figs. 20 –  
8    25 illustrate details of the gripper blocks common to both embodiments 100,200.  
9    The novel concepts are common between the two preferred embodiments  
10   described herein.

11           Having reference to Fig. 1, a new coiled tubing injector 100 is  
12   provided which is characterized by a linearly extending section 101. This "linear"  
13   injector 100, in combination with a suitable support or mast (Fig. 12,27) can  
14   provided superior pulling capability, is gentle to coiled tubing and can also  
15   handle full diameter tubing, providing substantially all the advantages of both  
16   conventional sectional drill tubing and coiled tubing.

17           More particularly, and having reference to Fig. 1-5 and 16, the  
18   linear injectors 100,200 respectively comprise a continuous chain conveyor 102  
19   fitted to a frame 109 having a chain 103 extending endlessly therearound.

20           As shown in Figs. 2, 4 and 16-18, the continuous conveyor 102 is  
21   fitted with upper and lower drive sprockets 104,105. The endless chain 103 is  
22   fitted with a multiplicity of coiled tubing gripper blocks 106; one block 106 per link  
23   of the chain 103. The blocks 106 move with the chain conveyor 102. The blocks  
24   106 are pivotally interconnected with pins 107 which engage the upper and lower

1 driv sprock ts 104,105. The moving gripper blocks 106 are formed with  
2 grooves 108 for accepting coiled tubing 110.

3

4<sup>x</sup> Injector Linear Section

5 As shown in Figs. 1, 3 and 5, one portion of the continuous  
6 conveyor 102 forms the linear section 101. A linear array 111 of complementary  
7 hold-down rollers 112 exert a normal force on the coiled tubing 110, urging it into  
8 the moving gripper blocks 106 and thereby frictionally engaging the coiled tubing  
9 110 with minimal damage caused thereto. The relatively long length of the linear  
10 section 101, combined with a uniform coiled tubing gripping force, imposes large  
11 pulling force on the coiled tubing 110, resulting in significant pulling capability.

12 As a result, the capability of the linear injector 100 is even further  
13 expanded to include the injection and pulling out large bore coiled tubing 110 in  
14 deep well drilling operations.

15 In more detail, and referring to Figs. 2,3 and 5, the linear array 111  
16 of hold-down rollers 112 comprises a multiplicity of these rollers 112, distributed  
17 along, parallel to and facing the linear section 101 of gripper blocks 106. The  
18 rollers 112 have corresponding grooves 113 to accept the coiled tubing 110.

19 A corridor 114 is formed between the opposing grooves 108,113 of  
20 the gripper blocks 106 and rollers 112. The coiled tubing 110 extends through  
21 the corridor 114.

22

1    Blocks & Block Track

2                    The moving gripper blocks 106 are movably support d by skate or  
3 track means 120, located along the linear section 101, so as to resist the  
4 reaction force produced by the rollers 112 and thereby grip the coiled tubing 110  
5 extending in the corridor 114 therebetween.

6                    In first and second block embodiments shown in Figs. 1 - 6, 20-25  
7 respectively, the moving gripper blocks 106 themselves (roller gripper blocks  
8 106a) form the continuous chain conveyor 102. This is in contrast to the  
9 independent assembly 106b of blocks 106 and chain 103 illustrated in a third  
10 embodiment shown in Figs. 19a - 19c.

11                    Having reference to Figs. 20 and 21, in a first block embodiment,  
12 each roller gripper block 106a comprises a block 106 formed with a semi-circular  
13 groove 108, fitted with a replaceable insert 121 which is sized to match the  
14 diameter of the coiled tubing 110 being used. The insert can have a tungsten  
15 carbide surface finish (not visible) placed thereon for increased longevity and  
16 gripping (friction) capability. The roller gripper blocks 106a have an offset link  
17 configuration having narrow first bifurcated prongs 122 and second wider  
18 bifurcated prongs 123. Adjacent roller gripper blocks 106a,106a interconnect  
19 with the first prongs 122 fitting between the wider second prongs 123 of the  
20 immediately adjacent roller block 106a with pin 107 pivotally connecting them  
21 together.

22                    In a second roller block embodiment shown in Figs. 22 - 25, again  
23 the moving gripper blocks 106 themselves form the continuous chain conveyor  
24 102 and are fitted with the grooves 108 and inserts 121. In this embodiment, two  
25 types of roller blocks 116 are provided; one block 116a having closely spaced

1 links 117a and another block 116b with widely spaced links 117b. Each roller  
2 block 116a,116b is mounted to (or formed with) a pair of parallel links  
3 117a,117b, spaced sufficiently to enable the upper and lower sprockets 104,105  
4 to pass therebetween (Fig. 25). As shown in Fig. 24, the roller pin 107, as per  
5 the first embodiment, passes transversely through the links 117a,117b for  
6 pivotally pinning them together.

7           Having reference to Fig. 25, the narrow spaced links 117a fit  
8 between the widely spaced links 117b, the narrow and widely spaced link roller  
9 blocks 116a,116b connected in alternating fashion and, when pinned together,  
10 form the continuous chain conveyor 102, shown wrapped about a sprocket  
11 104,105.

12           The interconnecting pins 107 of any block 106 or specific  
13 configuration 106a,116a,116b are engaged by the upper and lower drive  
14 sprockets 104,105. As shown in Figs 21,24,25 and 17, the transverse or distal  
15 end of each pin 107 supports a idler assembly 122 having a bearing 123 and  
16 idler 124 which engages a backing track 120, enabling the blocks 106 to resist  
17 the normal force imposed by the rollers 112. The backing track 120 is  
18 conveniently formed by flat bar atop parallel "I"-beams 123 forming the structure  
19 or frame 109 of the linear injector 100.

20           In a third embodiment shown in Figs. 19a-19c, separate gripper  
21 blocks 106c are provided as a separate component mounted to brackets 130 on  
22 roller chain 131. The continuous conveyor 102 can be supported along its linear  
23 section 101 by a linear skate 132, backing the roller chain 131.

24           The chain conveyor 102 is driven at one or both of the upper and  
25 lower sprockets 104,105 preferably with primer movers 133 such as hydraulic

1 motors or planetary drives. As shown in Fig. 1, the path of the continuous chain  
2 conveyor 102 forms a periphery about an interior 134. Efficient use of the  
3 interior 134 results in a compact and narrow arrangement wherein four prime  
4 movers 133 are nested within the injector interior 134, using belted or chain  
5 transmission 135 coupled to sprockets 136 to drive the conveyor 102. In a less  
6 compact arrangement, illustrated in the embodiment of Figs. 16-18, a direct  
7 planetary drive 137 is shown coupled and extending laterally and directly off the  
8 sprocket.

9           The prime movers 133 are reversible for providing injection force in  
10 one rotational direction and pulling force in the other rotational direction. The  
11 pitch of the conveyor chain 102 is minimized to reduce the diameter of the upper  
12 and lower sprockets 104,105, resulting in a reduced driving moment and  
13 reduced drive size.

14

#### 15 Holddown Rollers

16           Having reference to Fig. 4, biasing means are provided for urging  
17 holddown rollers 112 into engagement with the coiled tubing 110. First and  
18 second telescoping members 140,141 extend between the rollers 112 and the  
19 track 118 or frame 109. Spring means 142 (Fig. 10) are placed between first and  
20 second members 140,141 for maintaining compression on the coiled tubing 110.  
21 More particularly, a lateral and levered arrangement of complementary pairs of  
22 fixed and adjustable struts 143,144 urge holddown rollers 112 towards the  
23 gripper blocks 106 for sandwiching the coiled tubing 110 therebetween. The  
24 adjustable struts 144 form the spring means 142 and telescoping members

1 140,141. A plurality of these lever arrangements are provided in the array 111  
2 along the injector's linear section 101.

3 Referring to Fig. 2 and 4, the rollers 112 are set using adjusting  
4 struts 144 for exerting a fixed and consistent force for the size of coiled tubing  
5 110 used. Shown individually in Fig. 9 and in cutaway detail in Fig. 10, each  
6 strut 144 comprises a cylindrical housing 145 (of the first telescoping member  
7 140), a shaft 146 (the second telescoping member 141) and conical spring or  
8 load-indicating washers 142. The strut 144 can only be pulled from the housing  
9 145 by compression of the washers 142. The struts 144 set the appropriate load  
10 for maximizing normal force on the roller 112 without damaging the coiled tubing  
11 110. Other elastomeric load-indicating washers (not shown) may also be used.

12 The complementary fixed struts 143 provide the fulcrum from which  
13 the rollers 112 are levered into engagement with the coiled tubing 110. Further,  
14 the fixed struts 143 incorporated a coarse threaded adjustment 146 for setting  
15 the position of the holddown rollers 112.

16 Referring to Fig. 8, the holddown rollers 112 themselves are  
17 provided in parallel pairs, rotatably fitted to a rocker housing 150. The rocker  
18 housing 150 has a single pivot shaft 151 which is secured at each end to the  
19 fixed and adjustable struts 143,144. The pivot and rocker housing 151,150  
20 ensures that load is distributed between the two parallel rollers 112.

21 Optionally, and referring to Fig. 18, in optional embodiments, the  
22 force produced by the roller 112 can be dynamically adjusted using hydraulic  
23 actuators 147, further enabling the rollers 112 to adjust the normal gripping force  
24 or optionally to temporarily and sequentially lift the rollers 112 off the coiled  
25 tubing 110 or sectional tubing to pass an upset or other diameter variation.

1 Accordingly, the long linear section 101 can also accommodat long rigid  
2 sectional strings (not shown). As a result, the linear injector 100,200 can be  
3 used in a variety of heretofore restricted applications including the injection of  
4 long strings of downhole tools or in the case of drilling operations, injecting and  
5 pulling out large bore coiled tubing 110 in deep well drilling operations.

6 For maintenance and adjustability, the rollers 112 can be grouped  
7 arrays 149 (Fig. 17), each having several rollers 112 (e.g. five) minimizing the  
8 number of hydraulic actuators 147.

9 Referring once again to Figs. 5 and 17, a tubing straightener 160 is  
10 located at the upper end 41 of the linear injector 100,200 so that coiled tubing  
11 110, without appreciable residual bend, is caused to enter the injector, reducing  
12 load on the gripper blocks 106 and rollers 112 and further so that coiled tubing  
13 110 leaves the linear injector 100,200 straight. When withdrawing or pulling the  
14 coiled tubing 110 back up, the straightener 160 re-bends the tubing 110 to the  
15 lowest stress possible unsupported shape – preferably a parabolic shape.

16

#### 17 Linear Tubing Pull Test Example

18 Having reference to Fig. 11, four gripper blocks 106 and  
19 corresponding holddown rollers 112 were constructed according to Figs. 7 and 8  
20 and in opposed relation to form the corridor 114. The gripper blocks 106 were  
21 anchored to a base structure 164 so as to be immovable. A length of tubing 110  
22 was installed in the corridor 114 and affixed to a first hydraulic pull cylinder 165.  
23 A second hydraulic normal-force cylinder 166 forces the holddown rollers 112  
24 into engagement with the length of tubing 110. Any movement of the tubing 110,



1 indicating slippage of the tubing 110 in the gripper blocks 106, was measured by  
2 a dial indicator (not shown).

3 The first pull cylinder 165 had a  $12.5 \text{ in}^2$  effective area or 1,250 lbs.  
4 of pull force per 100 lbs. hydraulic pressure.

5 The second normal force cylinder 166 had a  $5.15 \text{ in}^2$  effective area  
6 capable of producing a total normal force of 20,600 lbs. at a pressure of 4000  
7 psi. For four rollers, this became 5,150 lbs. per roller.

8 The four gripper block inserts 121 (not detailed) were sprayed with  
9 a friction enhancing tungsten carbide coating.

10 The pressure of the first pull cylinder 165 was increased until  
11 slippage occurred. Slippage occurred consistently at about 1000 psi.  
12 Accordingly, the pull force was about 12,500 lbs or each of the four gripper  
13 blocks 106 were holding up to  $12,500/4$  or 3,125 lbs. each. With the imposed  
14 normal force of 5,150 lbs. each, the coefficient of friction at slip was about  
15  $3,125/5,150$  or 0.61. Assuming an efficiency of 80% to account for drive and  
16 friction losses in a full injector 100,200, the effective coefficient of friction is only  
17  $0.5 (0.61 \cdot 0.80)$ .

18 When extrapolated to a linear injector having an anticipated 48  
19 blocks 106 and corresponding rollers 112, the corresponding and effective pull  
20 strength for 48 blocks would be  $48 \cdot 3,125 \text{ lbs.} \cdot 0.80 = 120,000 \text{ lbs.}$  at the point  
21 of slippage.

22

1    Hybrid Drilling Systems

2                   The linear injector 100,200 is particularly suited to use in  
3    combination with one or more arrangements of apparatus for conventional  
4    sectional drilling.

5                   In a first hybrid embodiment (Figs. 12-25), a conventional mast is  
6    implemented constructed in a style in common use today . A coiled tubing linear  
7    injector is arranged for installation and access through the same V-door as is  
8    used for handling conventional sectional tubing. Simply, in this arrangement, all  
9    drilling activity is performed through the same mast access.

10                  In a second hybrid embodiment (Figs. 27-35b), a portable, dual  
11    duty mast is provided which enables access from two sides. Accordingly, a  
12    coiled tubing injector can be arranged for access from one open side and  
13    sectional tubing from the second open side.

14                  In instances where 2000 meters of well are to be drilled, typically  
15    one would utilize a mast capable of handling stands of 2 or 3 lengths of tubing.  
16    This requires a mast of 130 – 140 feet in height. However, by combining  
17    sectional with coiled tubing, a mast of only about 75 feet in height is required –  
18    set only by the length of tubulars being handled, the usual constraint being  
19    "Range-3", 45 ft. long casing.

20                  Further, coiled tubing has only a cumulative weight of about 7  
21    lbs./ft. compared to about 16 lbs./ft. with the associated sectional tubing having  
22    heavy collars and thicker walls.

23                  Now it is appropriate to drill only about 4-500 ft. of surface hole with  
24    sectional tubulars, place surface casing, and drill the remainder of even very  
25    deep hole with coiled tubing.

1           With the ability to handle sectional tubulars, it is possible to quickly  
2 assemble drilling Bottom Hole Assemblies and drill immediately with coiled  
3 tubing.

4<sup>i</sup>

5   Single Side Hybrid System

6           More particularly, having reference to Fig. 12, a conventional,  
7 sectional tubing, drilling rig (conventional rig) 201 is positioned at a well 202.  
8 The well is fitted with a Blow-out Preventor (BOP) 202b. A novel, coiled tubing  
9 transport rig 203 (CT Rig), according to the present invention, is also positioned  
10 at the well 202. For reasons elucidated in greater detail below, the preferred CT  
11 Rig 203 incorporates only means for transporting the novel injector 200 and does  
12 not include pumps and the like, and thus is substantially less complicated and  
13 less expensive than prior art coiled tubing injector rigs.

14           More particularly, the CT Rig 203 comprises a mobile trailer or  
15 truck frame 205 having a coiled tubing spool 206 mounted thereon.  
16 Conventional means (not detailed) are provided for managing coiled tubing  
17 dispensing and retrieving, including spool drives.

18           A curved feed arch 207 assists in directing the coiled tubing 110  
19 approximately along a parabolic loop 208. The parabolic loop 208 has been  
20 found to be a low stress configuration for the loop of coiled tubing.

21           Best shown in Fig. 14, the CT Rig 203 forms a transport bed 208  
22 for storing and transporting the linear injector 200 to the well 202. Once at the  
23 well, rather than utilizing the transport rig 203 to support the linear injector 200, it  
24 is mounted and supported in the mast 204 of the conventional rig 201.

1           As illustrated, the conventional rig 201 may comprise a mobile  
2 trailer 210, the mast 204 rising from substructure and a rotary table 211, at the  
3 drilling floor 212, to draw works 213 in the crown 214 and means for suspending  
4 the linear injector 200 in the mast 204.

5           The upper end 215 of the continuous conveyor 200 is fitted with  
6 second guide arch or gooseneck 216 for guiding the coiled tubing 110.

7           As shown in plan in Fig. 13, the CT Rig 203 and conventional rig  
8 201 are oriented out of alignment for retaining full functionality of the  
9 conventional rig 201. Accordingly, a catwalk 217 and pipe rack 218 are able to  
10 access the drilling floor 212. Further, mud pumps 218 and mud tanks 219  
11 accompany the conventional rig 201.

12           As described above and shown in Fig. 16 the linear injector 200 is  
13 a continuous conveyor 102 having an upper 215 and a lower end 225. As  
14 shown in Figs. 28 and 29, the lower end 215 of the linear injector 200 is  
15 rotationally pinned in the mast 204 above the drilling floor 212. The linear injector  
16 200 is hoisted into the mast 204. As shown in Fig. 15, a cable 220 from the  
17 mast's draw works 213 is directed about an idler 221 located about the  
18 monkeyboard and is attached to the upper end 215 of the linear injector 200.

19           Using the draw works 213 and cable 220, the upper end 215 is  
20 hoisted upwardly, pivoting the linear injector 200 about the bottom end 225 and  
21 into position. The linear injector 200 is aligned with the BOP 202b. The linear  
22 injector 200 is secured for suspending it in the mast 204.

23           The linear injector 200 can be alternated between two positions  
24 within the mast 204. In a first position, the injector is aligned with the BOP 202b  
25 for injection and withdrawal of coiled tubing 110. In a second position, the linear

1 injector 200 is shifted or set aside in the mast 204 to take the injector out of  
2 alignment from the BOP 202b. When out of alignment, the mast 204 can b  
3 used in a conventional manner; more specifically to enable sectional tubulars to  
4 be pulled up the catwalk 217 and into the mast 204 and utilizing the rotary table  
5 213 for making up the tubular's threaded joints.

6 By combining a conventional mast 204 with coiled tubing capability,  
7 a high capacity draw works 213 and a rotary table 211 are now available.  
8 Further, the physical distance placed between the conventional rig 201 and the  
9 source of the coiled tubing (the spool 206) enables the formation of a large  
10 radius parabolic loop 208 further allowing the injector rig to utilize large coiled  
11 tubing diameters, including 3.5 inch diameter typical for use in conventional rigs.  
12 The long linear injector 200 is capable of dealing with large lengths of coiled or  
13 sectional tubing. Further, use of the large fluid bore of 3.5 inch tubing 110  
14 reduces fluid friction pumping power requirements from about 1000 HP to only 5-  
15 600 HP at 5,000 feet. It is postulated that a 5,000 foot deep well can be drilled in  
16 about ½ the time conventionally required due to the elimination of the need to  
17 make up joints every 30 feet.

18 The ability to use large bore 3.5", straightened coiled tubing 110  
19 better mimics, as close as possible, performance capable with conventional  
20 sectional tubing; now providing: a large pulling capability needed for deep  
21 drilling; providing straight tubing with weight on bit control suitable for controlled  
22 drilling immediately; and even for drilling surface hole. Further, the  
23 aforementioned problems associated with residual bend can be avoided.

24 It has been determined that a 20 foot long linear section 101  
25 provides pull capability on 3.5 inch tubing of about a maximum of 150,000

1 pounds, but if oil contaminated (soaked wet), this capability can drop to about  
2 50,000 pounds. In practice, the pull capability would be in excess of 80-100,000  
3 lbs.

4           The length of the linear section 101 is configurable depending upon  
5 the driving force required. Maximum length would be limited by the working  
6 height within the mast 204. For instance for a working height of about 50 – 60  
7 feet, normally provided for making up stands of sectional tubulars, the linear  
8 section 101 of the injector 200 could be upwards of 30 feet tall. The straightener  
9 160 and a coiled tubing guide gooseneck must also be accommodated in the  
10 mast 204.

11           Further, the hybrid arrangement simplifies the assembly and use of  
12 Bottom Hole Assemblies (BHA). A BHA includes the bit, mud motor and  
13 measurement equipment, which must be made up and can be in the order of 30  
14 feet in length. Conventional coiled drilling units have tried various means to  
15 make up the BHA, requiring the various pieces to be threaded together. This is  
16 usually a labor intensive job because coiled tubing units are not normally set up  
17 to rotate tubing to make up the joints. Occasionally drill collars are also threaded  
18 onto the BHA to provide startup drilling weight or improve linear stability.

19           Further, by combining a conventional mast 204 with the linear  
20 injector 100,200, the capital costs of the whole operation are reduced. A rig  
21 transporting a linear injector 100,200 need not have a mast, nor fluid pumping  
22 equipment and can simply include the coiled tubing injector 200 and spool 206  
23 The conventional mast 204 provides the capability of lifting at the required high  
24 pull forces and through the use of the rotary table 31 enables readily making up  
25 BHA and connections onto the non-rotating coiled tubing 11.

1           In yet another application, as shown in Fig. 26, the linear injector  
2 200, applied without a conventional mast, is particularly well suited for shallow  
3 directional drilling or the insertion of downhole tools such as pumps or for  
4 workovers, and is able to provide continuous, straightened tubing into any well,  
5 including a slant wellhead and BOP 202b. Without the need for a rotary table or  
6 strong draw works, the linear injector 200 can be located on its own trailer 203  
7 and does not require further mast superstructure. As shown in Fig. 26, the linear  
8 injector 200 can be transported prone (stage (a)), raised partially for injection  
9 through a slant wellhead/BOP 202b (stage (b)) or raised completely for injection  
10 down a vertical well (stage (c)). A BHA for directional drilling or a pump can be  
11 pre-assembled and carried on an integrated coiled tubing injector rig for injection  
12 without additional equipment.

13

## 1    Dual Duty Hybrid System

2                    Having reference to Fig. 27, in a preferred embodiment of th  
3    system, two rigs are again provided; one of which provides sectional tubing and  
4    the second providing coiled tubing. A first rig 301 comprises a collapsible mast  
5    304 on a first trailer, a substructure, rotary tubing drive means 311 (table or  
6    power swivel), side shifting crown 314, dual blocks 313a and dual drawworks  
7    313. In this description, dependent upon the context, the term drawworks 313b  
8    is also used to describe the winches 131d, cable 313e, crown pulley 313b and  
9    blocks 313a in combination. Further, while the block 313a also includes a hook  
10   313c, it is understood that drawworks 313 includes means for attaching various  
11   tools, such as a hook 313c for handing elevators, swivels and the injector 100.

12                   An integrated hydraulic system (not detailed) powers the  
13   drawworks 313, side-shifting crown 313b, rotary table 311 and lifts the  
14   collapsible mast 304.

15                   A second rig 303 comprises a coiled tubing injector and a reel of  
16   coiled tubing on a second trailer. Suitable support equipment is provided such  
17   as a mud system, mud pump and control house.

18                   Having reference to Fig. 28, the first rig 301 is transported to a well  
19   in a transportable, collapsed form. The substructure 350 is located at the  
20   trailer's back end 351. The substructure 350 is optionally equipped with a  
21   wellhead and BOP 302b for centering over the well 302. The rotary table 311 is  
22   installed in the substructure 350 for positioning over the center of the BOP 302b.  
23   The mast 304 has its crown 353 and a base 354 formed of two support  
24   structures 355,356 pivotally connected at the crown 353 and having a transverse  
25   dimension about that of the width of the trailer 305. In its collapsed form, the two



1 support structures 355,356 lie substantially parallel to the trailer 305, arranged  
2 as one lower support structure 355 and one upper support structure 356. The  
3 clearances of the top of the substructure 350 and the top of the upper support  
4 structure 356 are both optimally low enough for highway travel.

5 The lower support structure is pivotally connected at its base 355b  
6 to the substructure 350. The base 356b of the upper support is free for  
7 subsequent pinning at 356c when erect. Hydraulic rams 357 are located  
8 between the mast's lower support structure 355 and the trailer 305 and, when  
9 energized, drive the mast 304 into the erect position.

10 Having reference to Fig. 29, the coiled tubing injector 100 is  
11 positioned at the second rig's back end 370. A coiled tubing supply reel 306 is  
12 positioned mid-trailer and is capable of storing up to 6500 feet of 3-1/2 inch  
13 tubing, 8500 feet of 2-7/8" tubing or 12,000 feet of 2-3/8" tubing.

14 Having reference to Figs. 30a, 30b, the erected lower and upper  
15 support structures 355,356 are designed to support the compressive loads of  
16 pulling tubing without the requirement for significant cross bracing. As shown in  
17 the end view of the mast in Fig. 30b, each of the lower and upper support  
18 structures 355,356 are formed of a pair of spaced legs 371 constructed of hollow  
19 structural tubing depending downwardly from the crown 353. Between the legs  
20 371 is formed a large open side 372, suitable for tubing access. The crown 353  
21 comprises a horizontal beam 373 and ties the two pairs of legs 371 together.

22 As shown in Fig. 27 and 30a, when erected, the crown 353 is  
23 positioned over the well 302. The trailer 305 itself forms a catwalk 317 for  
24 handling conventional sectional tubing or tubulars 310.

1           Referring to both Figs. 30a and 30b, the crown 353 is shown  
2 equipped with a shifting crown 313b comprising a first block 381 and second  
3 block 382 movable laterally in the crown 353. The first and second blocks  
4 381,382 are alternately positionable one or the other over the well 302. Each  
5 block 381,382 has means, such as a hook 313c, for attaching various tools.  
6 Specifically, as shown in Fig. 30b, the second block 382 is shown, fitted with a  
7 hook 313c, a swivel 383 and a kelly 384. The kelly 384 is driven by the rotary  
8 table 311 for drilling purposes.

9           Having reference to Fig. 31a, the first and second rigs 301,303 are  
10 arranged back end 351 to back end 371. The mast 304, when erected, has a  
11 first side open 374 to the trailer 305 of the first rig 301 for forming a catwalk 317  
12 for drill pipe, casing or tubulars 310 generally. The opposing side of the mast  
13 304 is open to the second coiled tubing rig 303. Accordingly, lengths of sectional  
14 tubulars 310 can be handled or drawn up the first open side 374 from the first rig  
15 301; and coiled tubing 110 can be introduced from the second open side 375.

16           The coiled tubing rig 303 is not necessarily provided with a guide  
17 arch. Conveniently, a guide arch 316 is instead pivotally connected to and  
18 shipped with the mast 304. In preparation for use, the guide arch 316 is pivoted  
19 out from the upper support structure 356 so that it projects laterally therefrom.

20           Having reference to Figs. 31a, 31b and 32, the coiled tubing  
21 injector 100 is released from its shipping condition. One of the blocks 382 (the  
22 second block being shown) is lowered to capture the injector 100 for lifting it into  
23 the mast 304. As the injector 100 is lifted, the coiled tubing 110 is spooled off of  
24 the reel 306. An objective is to maintain a gentle loop, such as a parabolic  
25 shaped loop 308, for minimizing stress in the coiled tubing 110. Cables 385

1 stabilize the injector 100 as it is lifted and prevent it from colliding with the mast  
2 304.

3 Next in sequence at Figs. 33a,33b, the injector 100 is hung in the  
4 mast 304 and the coiled tubing 110 is aligned over the guide arch 316.

5 Finally, at Figs. 34a,34b, the injector 100 is landed on the  
6 substructure 350. A chair structure 390 at the bottom of the injector 100 couples  
7 with a corresponding base structure 391 on the substructure floor 312. The chair  
8 390 and base structure 391 telescope to permit several feet of vertical  
9 movement by the injector 100 but constrain the injector 100 aligned over the  
10 BOP 302b and well 302. The weight of the injector 100 and the coiled tubing  
11 110 is borne by the drawworks 313.

12 The coiled tubing 110 is set into the guide arch 316. The optimal  
13 curve in the coiled tubing is known as a parabolic loop 308. A level wind 392 is  
14 provided for stabilizing the coiled tubing 110 as it traverses across the reel 306  
15 as it spools on and off.

16 The coiled tubing injector 100 can be of any design which is  
17 capable of fitting in the mast 100 with enough spare lateral room to permit the  
18 injector 100 to be shifted out of the way and to permit the other block 381,382 to  
19 be aligned with the well 302. The linear coiled tubing injector 100 as described  
20 above meets such criteria. With the prime movers 133 offset from the drive  
21 sprockets and set within the interior 134 of periphery of the continuous chain, the  
22 depth of the injector 100 can be as narrow as three feet, and when idle, can be  
23 set aside in the mast 304, such as when handling tubulars 310 (drill tubing or  
24 casing).

1                   Drilling with coiled tubing 110 is now possible with the injector 100  
2 being operated as described above.

3                   In operation, the dual drawworks 381,382 are optimized to perform  
4 simultaneous operations and, as much as possible, minimize serial handling.  
5 For example, rather than utilizing a rotary table 311 and kelly 384 to both drill,  
6 then serially handle the next length of drill tubing 310, the first block and  
7 drawworks 381 could be lifting the sequential tubular 310 while the previous  
8 tubular is being run in with the second block and drawworks 382.

9                   Further, in another aspect, optimal modes for drilling, whether it be  
10 using sectional tubulars 310 or coiled tubing 110 may vary from site to site. The  
11 hybrid apparatus is particularly versatile for adapting to the individual cases.

12                  For example, drilling from surface in one instance may be best  
13 performed using conventional rotary drilling with a bit, drill collars and sectional  
14 tubing 310. In other instances, by making up a BHA using the rotary table 311  
15 and coupling with coiled tubing 110, surface hole can be drilled with the coiled  
16 tubing injector 100. Typically, surface hole is drilled and cased using threaded  
17 sectional tubulars and the remainder of the drilling is conducted with coiled  
18 tubing 110.

19                  One step-by-step example which illustrates the versatility of the  
20 dual duty hybrid drilling system is as follows.

21                  Arrive on site, position the tubular rig 310 at the well site, and erect  
22 the dual duty mast 304. Using the integrated hydraulics, lift the mast 304,  
23 pivoting on the lower legs 355b. Pin the upper legs 356a,356c, locking the mast  
24 304 over the substructure 350. The guide arch 316 is extended, clearing the  
25 portion of the mast aligned over the well 302.

1           Using the second drawworks 382, pick up a kelly 384 and swivel  
2 383 (assuming a rotary table 311 and not a power swivel). Using the first  
3 drawworks 381, pickup tubulars 310, including drill pipe and collars (assuming  
4 drilling surface hole with sectional tubing).

5           Drill surface hole. Once drilled, run surface casing tubulars and  
6 install a wellhead/BOP 302b.

7           Set the kelly 384 aside in the mast 304 or lay the kelly down,  
8 freeing the second drawworks 382. Using the first drawworks 381, lift a  
9 preassembled BHA, or lift BHA components and use the rotary table 311 to  
10 assemble the BHA. The first drawworks 381 can be side shifted in the crown  
11 353 to clear the mast 304 over the well 302.

12           If not already positioned, set the coiled tubing rig 303 with the  
13 injector 100 adjacent the well 302 and aligned to the mast 304. Using the  
14 second drawworks 382, lift the injector 100 into the mast 304 while spooling out  
15 coiled tubing 110. Land the injector 100 on the substructure 350 and couple the  
16 chair 309 and base structures 391. Set the coiled tubing 110 into the guide arch  
17 316.

18           Using the rotary table, connect the BHA to the coiled tubing and  
19 commence drilling with coiled tubing 110.

20           At any time, as required, the second drawworks 383 are shifted  
21 and the injector 100 is set aside in the mast 304. With the injector 100 out of the  
22 way, the first drawworks 381 could be fitted with elevators or with a swivel and  
23 kelly again for handling tubulars 310.

24

1                   **THE EMBODIMENTS OF THE INVENTION FOR WHICH AN**  
2 **EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS**  
3 **FOLLOWS:**  
4

5                   1. Apparatus for injecting coiled tubing into a wellbore from a  
6 source and withdrawing same, comprising:

7                   a chain conveyor driven about an endless path and having at least  
8 one linear section aligned with the wellbore;

9                   a multiplicity of gripper blocks conveyed and driven by the chain  
10 conveyor, the gripper blocks forming a substantially continuous coiled tubing  
11 support while traversing the linear section; and

12                  a linear array of a multiplicity of rollers in parallel and opposing  
13 arrangement to the linear section of the chain conveyor for forming a corridor  
14 between the rollers and the gripper blocks and through which the coiled tubing  
15 extends, the rollers urging the coiled tubing into frictional engagement with the  
16 gripper blocks so that as the gripper blocks are driven about the endless path  
17 they frictionally drive the coiled tubing along the corridor to inject or withdraw  
18 coiled tubing.

19

20                  2. The apparatus of claim 1 further comprising means for  
21 supporting the gripper blocks against the normal forces produced by the linear  
22 array of rollers.

23

24                  3. The apparatus of claim 2 wherein the means for supporting the  
25 linear section of the chain conveyor against normal forces comprises a

1 continuous track positioned on the opposing side of the chain conveyor from the  
2 gripper blocks.

3

4 4. The apparatus of claim 3 wherein the means for supporting the  
5 linear section of the chain conveyor against normal forces comprises at least one  
6 pair of idlers extending laterally from each gripper block, the idlers engaging and  
7 rolling along the continuous track for supporting the chain conveyor thereabove.

8

9 5. The apparatus of claim 4 further comprising biasing means for  
10 urging the rollers into engagement with the coiled tubing.

11

12 6. The apparatus of claim 5 wherein the biasing means comprises:  
13 a housing supporting one or more rollers rotationally therein;  
14 a first telescoping member extending from the roller housing;  
15 a second telescoping member secured relative to the track; and  
16 spring means between first and second telescoping members for  
17 urging the rollers into engagement with the coiled tubing.

18

19 7. The apparatus of claim 6 wherein each roller housing supports  
20 a pair of parallel rollers and further comprises a single pivot point to which the  
21 first telescoping member is pivotally connected.

22

1                   8. The apparatus of claim 1 further comprising:  
2                   a head sprocket over which the chain conveyor extends; and  
3                   a tail sprocket over which the chain conveyor extends so that the  
4 linear portion of the chain conveyor is formed along a line substantially tangent  
5 between the head and tail sprockets.

6  
7                   9. The apparatus of claim 8 further comprising one or more drives  
8 which rotate one or both of the head or tail sprockets.

9  
10                  10. The apparatus of claim 9 further comprising transmission  
11 means between each of the drives and the head and tail sprockets so that the  
12 drives can be located within the endless path.

13  
14                  11. The apparatus of claim 1 further comprising a tubing  
15 straightener positioned between the apparatus and the coiled tubing source.

16  
17                  12. The apparatus of claim 3 wherein the straightener is further  
18 positioned just preceding the corridor between the linear portion of the gripper  
19 blocks and the linear array of rollers.

20  
21                  13. The apparatus of claim 1 further comprising a continuous track  
22 positioned on the opposing side of the chain conveyor from the gripper blocks  
23 against which the gripper blocks bear upon application of normal forces  
24 produced by the linear array of rollers.

25



1           14. The apparatus of claim 13 further comprising at least one pair  
2 of idlers extending laterally from each gripper block, the idlers engaging and  
3 rolling along the continuous track for supporting the chain conveyor thereon.

4<sup>x</sup>

5           15. The apparatus of claim 14 further comprising a spring assembly  
6 for urging the rollers into engagement with the coiled tubing.

7

8           16. The apparatus of claim 15 wherein the spring assembly  
9 comprises:

10           a housing supporting one or more rollers rotationally therein;  
11           a first telescoping member extending from the roller housing;  
12           a second telescoping member secured relative to the track; and  
13           springs between first and second telescoping members for urging  
14 the rollers into engagement with the coiled tubing.

15

16           17. The apparatus of claim 16 wherein each roller housing  
17 supports a pair of parallel rollers and further comprises a single pivot point to  
18 which the first telescoping member is pivotally connected.

19

20           18. The apparatus of claim 1 further comprising:  
21           a head sprocket over which the chain conveyor extends; and  
22           a tail sprocket over which the chain conveyor extends so that the  
23 linear portion of the chain conveyor is formed along a line substantially tangent  
24 between the head and tail sprockets.

25

1           19. The apparatus of claim 18 further comprising on or more  
2 drives connected to one or both of the head or tail sprockets.

3

4           20. The apparatus of claim 19 further comprising transmission  
5 means between each of the drives and the head and tail sprockets so that the  
6 drives can be positioned within the endless path.

7

8           21. The apparatus of claim 1 further comprising a tubing  
9 straightener positioned between the apparatus and the coiled tubing source.

10

11           22. The apparatus of claim 21 wherein the straightener is  
12 positioned just preceding the corridor.

13

1                   23. A method of injecting coiled tubing into a wellbore from a  
2 source and withdrawing same, comprising:

3                   providing an injector apparatus, the apparatus having a chain  
4 conveyer extending about an endless path and having at least one linear section  
5 of a multiplicity of gripper blocks conveyed and driven by the chain conveyer and  
6 a linear array of rollers in parallel and opposing arrangement to the gripper  
7 blocks for forming a corridor aligned with the wellbore;

8                   straightening the coiled tubing;

9                   extending the straightened coiled tubing through the corridor;

10                  urging the linear array of rollers into engagement with the coiled  
11 tubing;

12                  supporting the multiplicity of gripper blocks against the normal  
13 forces produced by the linear array of rollers; and

14                  driving the chain conveyer along an endless path so as to drive the  
15 gripping blocks which frictionally drive the coiled tubing along the corridor to  
16 inject or withdraw the coiled tubing.

17

18                  24. The method as described in claim 23 wherein the conveyor is  
19 fitted with a plurality of idlers and the method further comprises:

20                  providing a continuous track; and

21                  supporting the idlers along the continuous track, which roll thereon  
22 during the driving step.

23

1                   25. The method as described in claim 23 wherein in the urging step  
2 the rollers are urged into engagement with the coiled tubing by a biasing means.

3

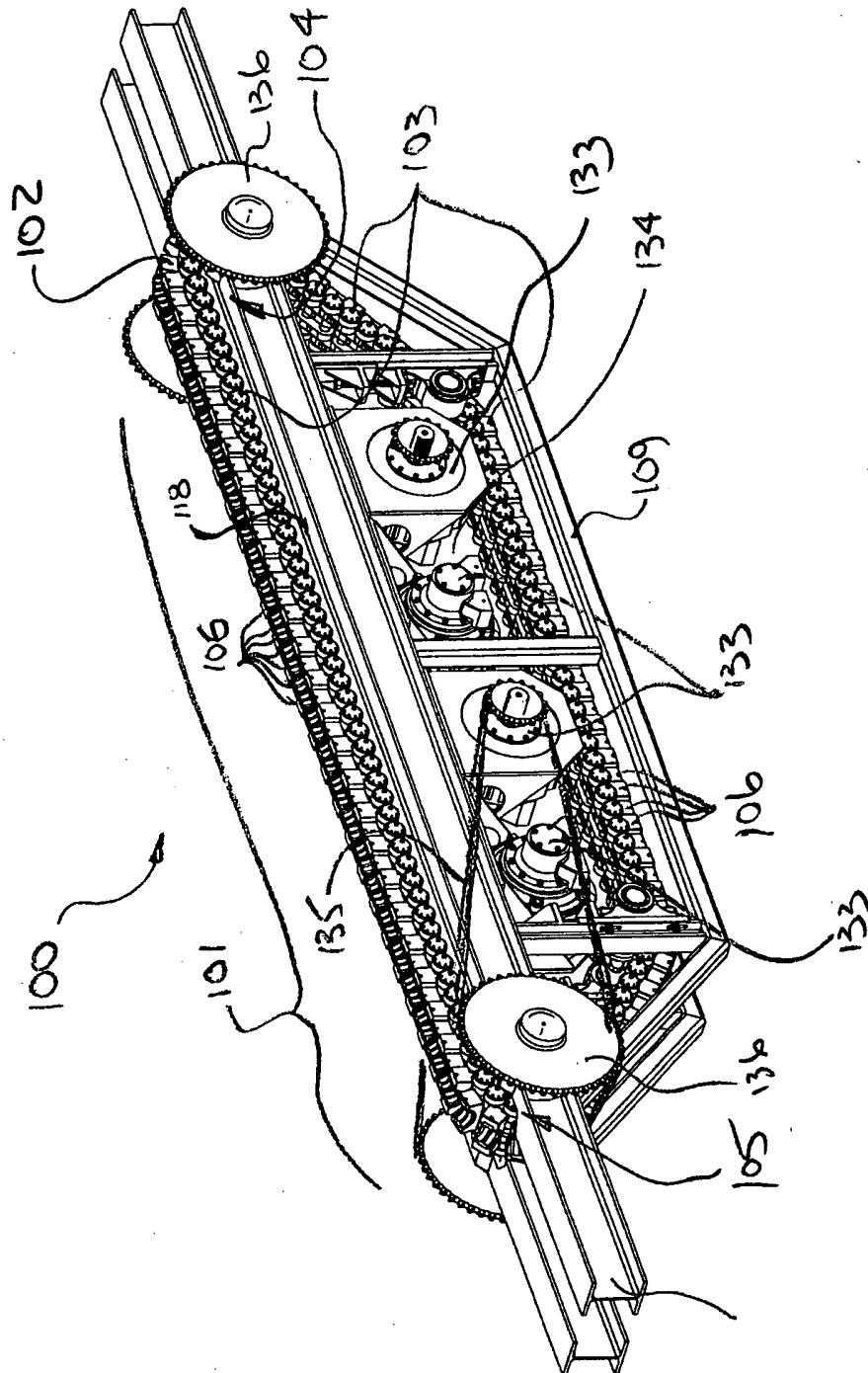
4                   26. The method as described in claim 25 wherein in the urging step  
5 the method further comprises levering the rollers into engagement with the coiled  
6 tubing using a spring.

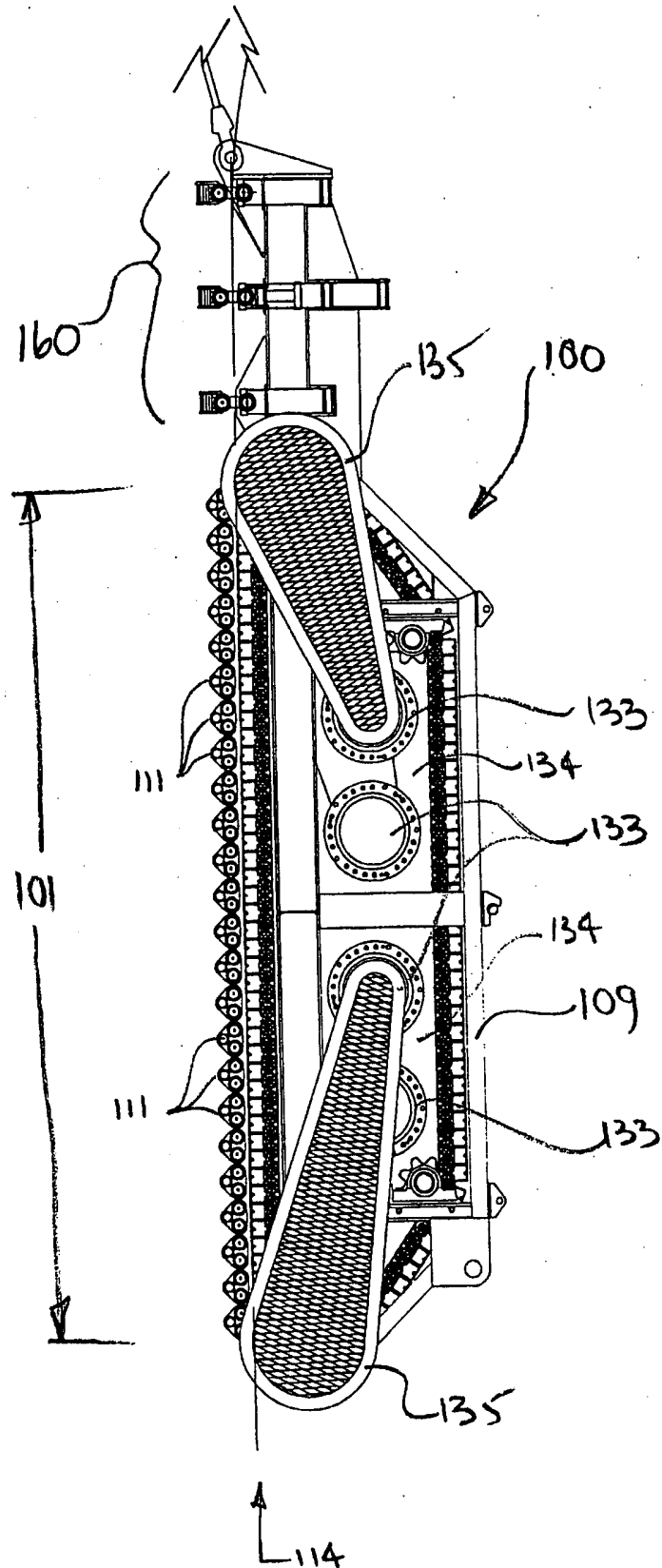
7

1                                    ABSTRACT OF THE INVENTION

2                    An injector is provided for injecting and withdrawing large diameter  
3 coiled tubing comprising a linear section of gripping blocks driven on an endless  
4 chain conveyor. The coiled tubing is forced into frictional engagement with the  
5 blocks by a corresponding linear array of rollers. The arrangement is gentle on  
6 the coiled tubing. The injector is not restricted in length and thus provides a  
7 linear driving section of configurable length for providing superior injection and  
8 pulling capacities. In combination with the strong draw works, mast and rotary  
9 table of a conventional rig enabling making up both sectional tubing for  
10 assembling BHA's, drilling surface hole and making up to non-rotating coiled  
11 tubing from the injector.

Fig. 1



**Fig. 5**

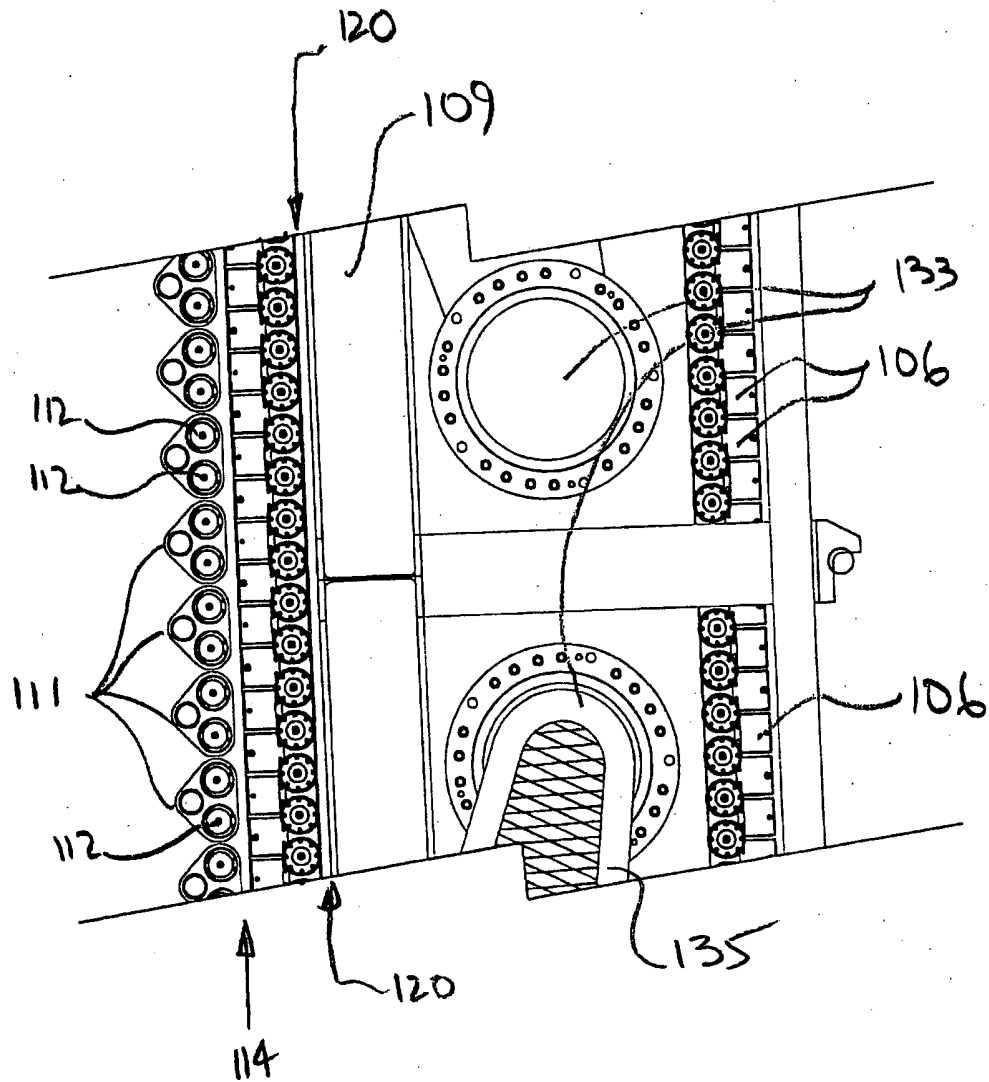
**Fig. 6**



Fig. 11

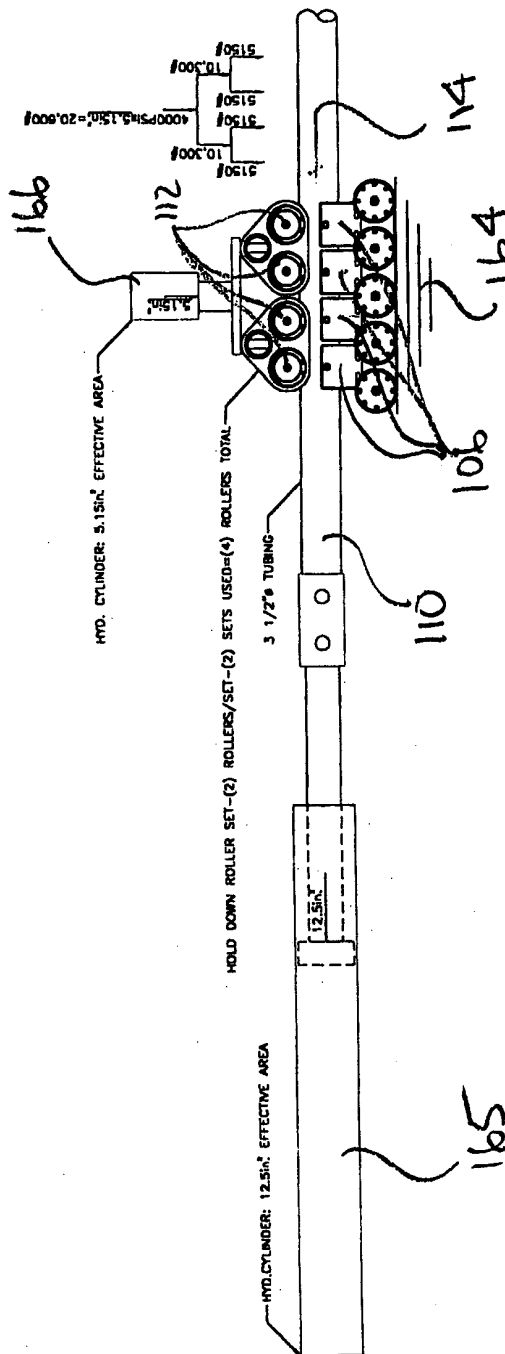
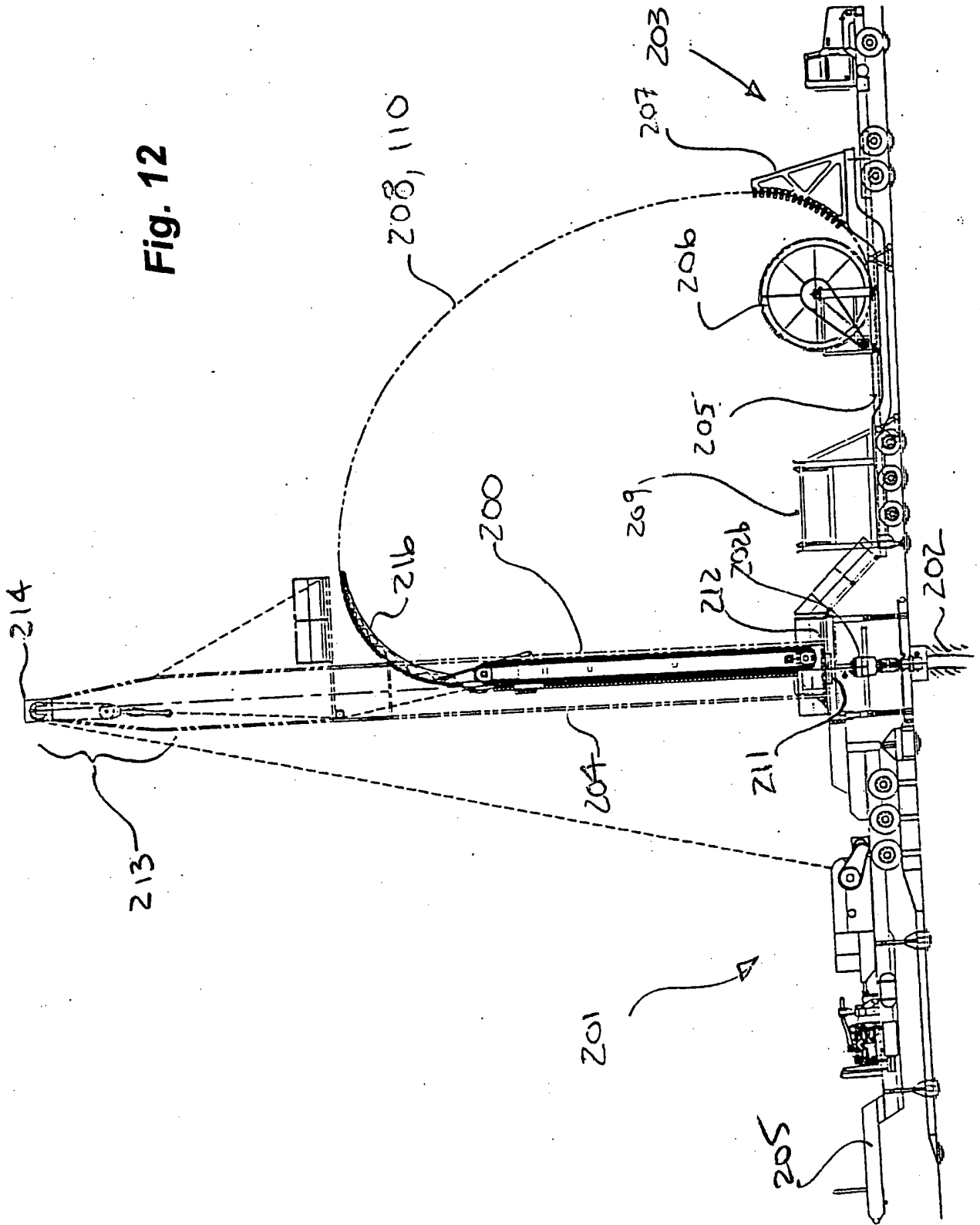
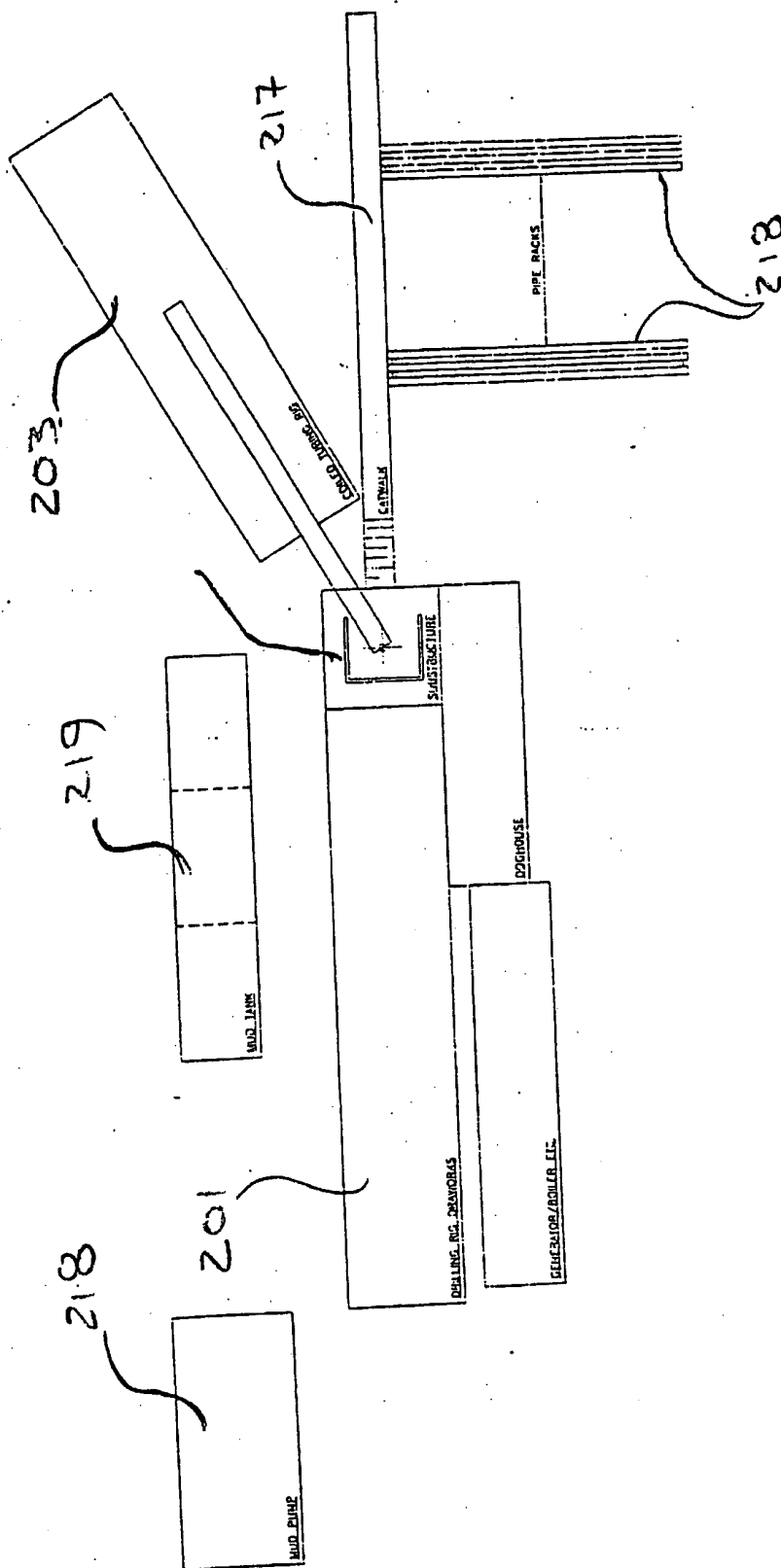


Fig. 12





**Fig. 13**

Fig. 14

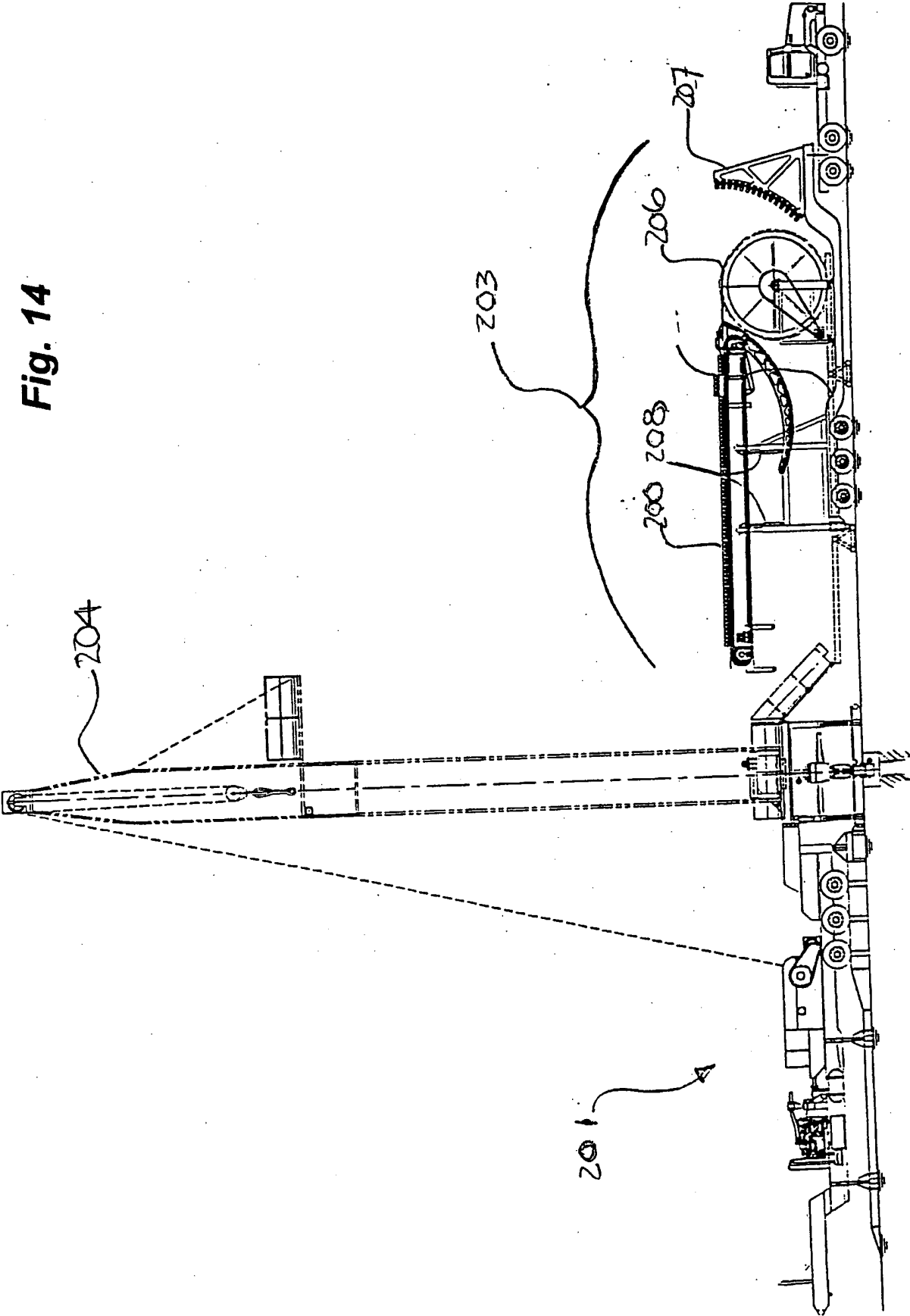
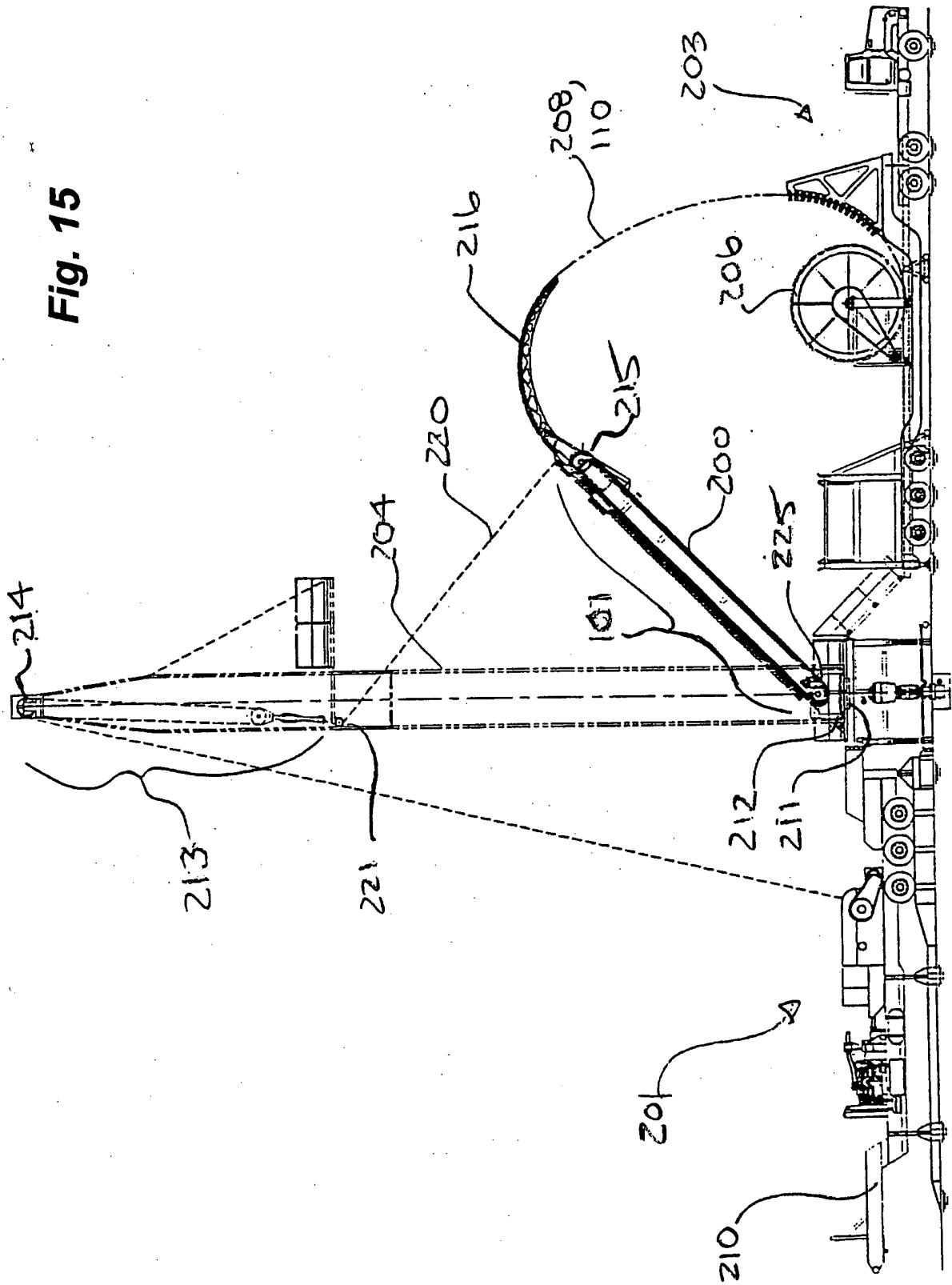
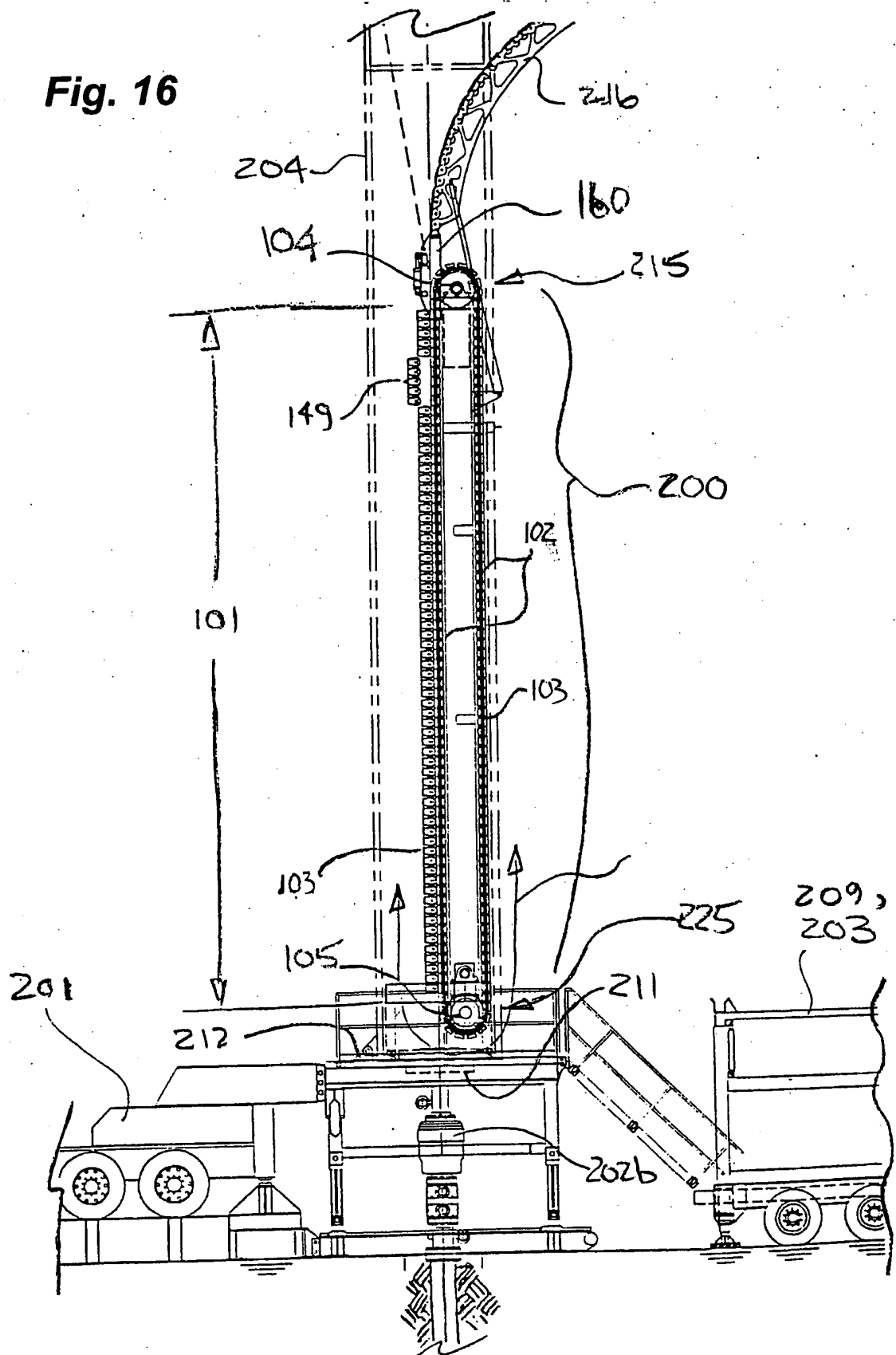
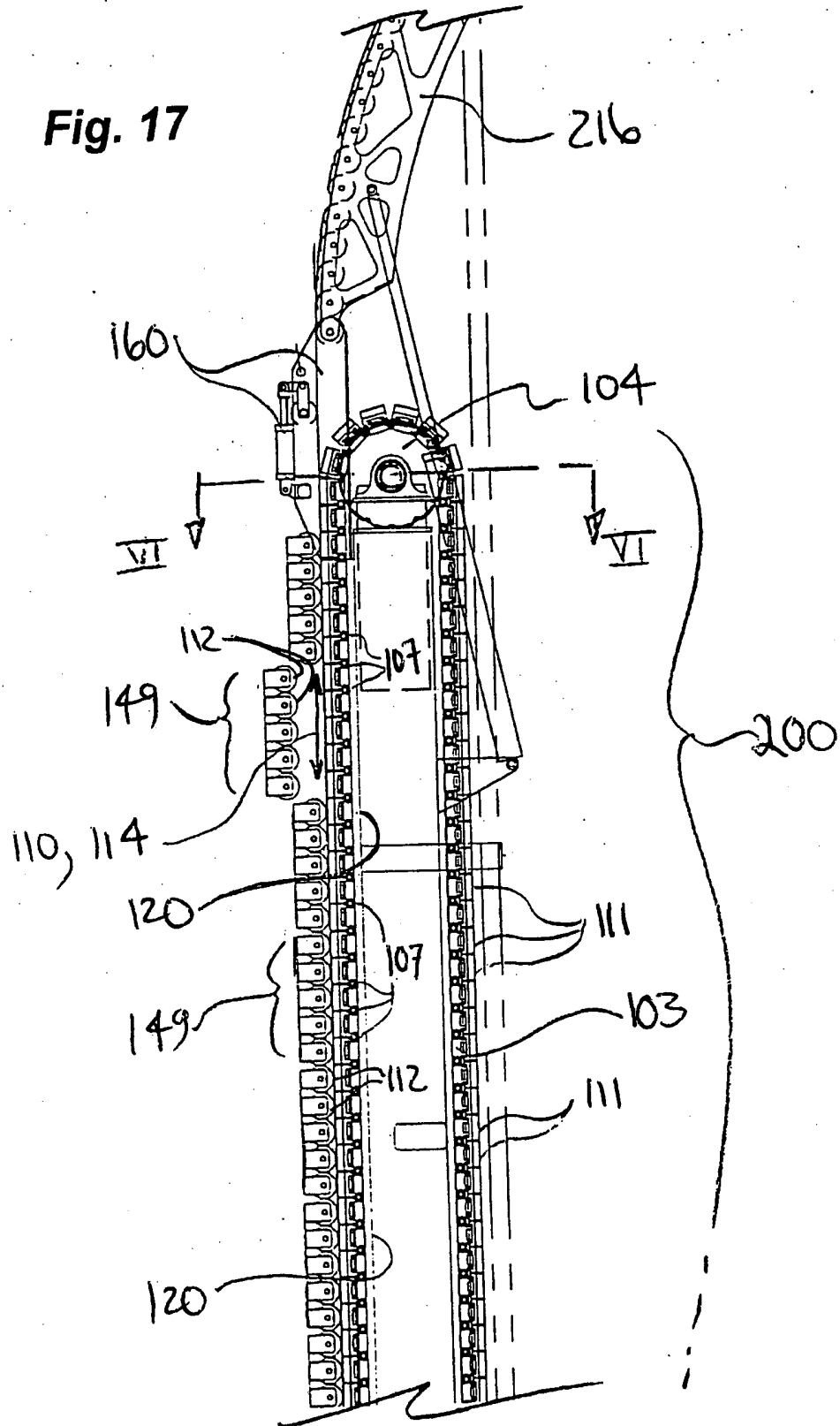


Fig. 15



**Fig. 16**

**Fig. 17**

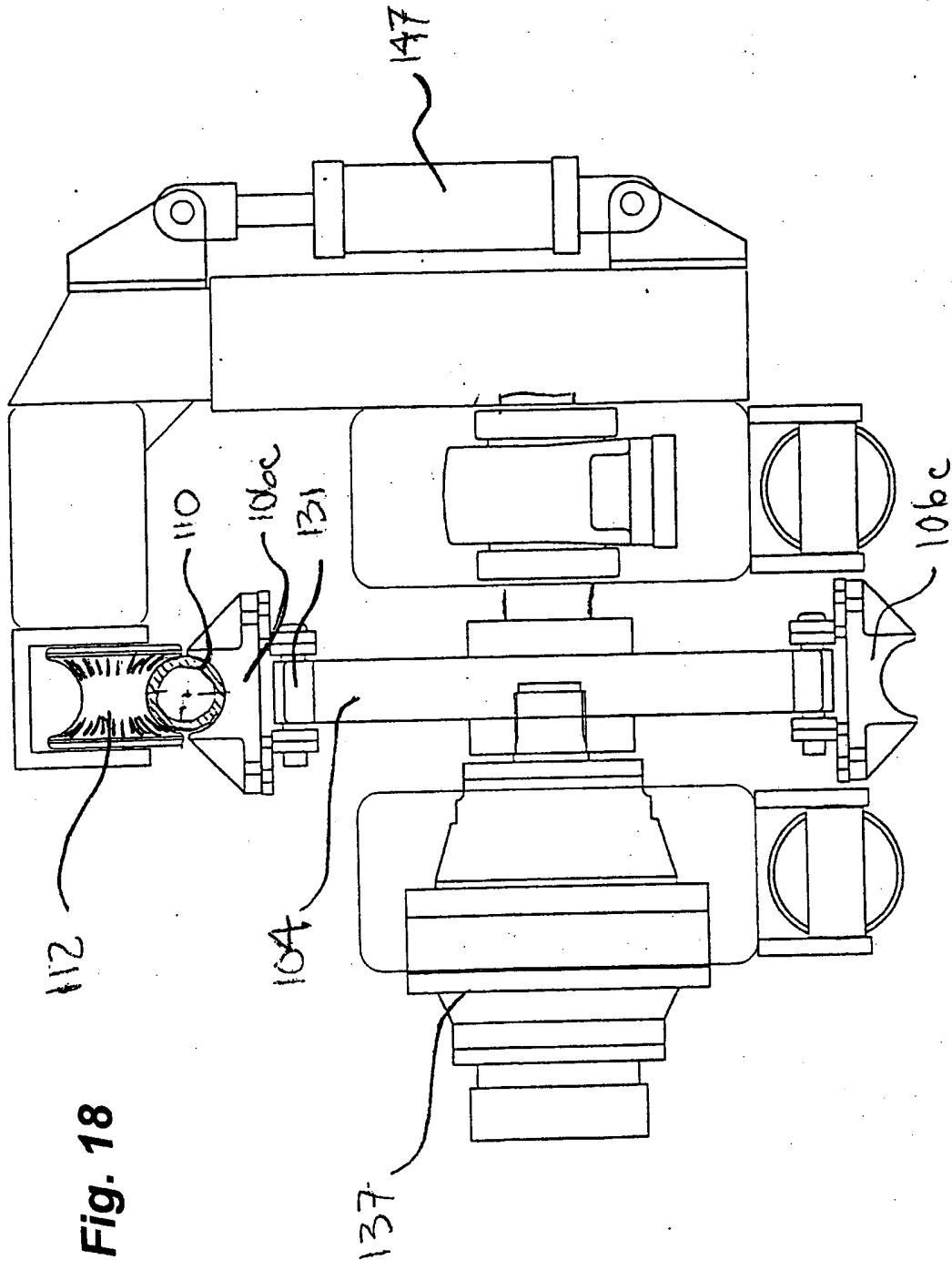


Fig. 18



Fig. 19a

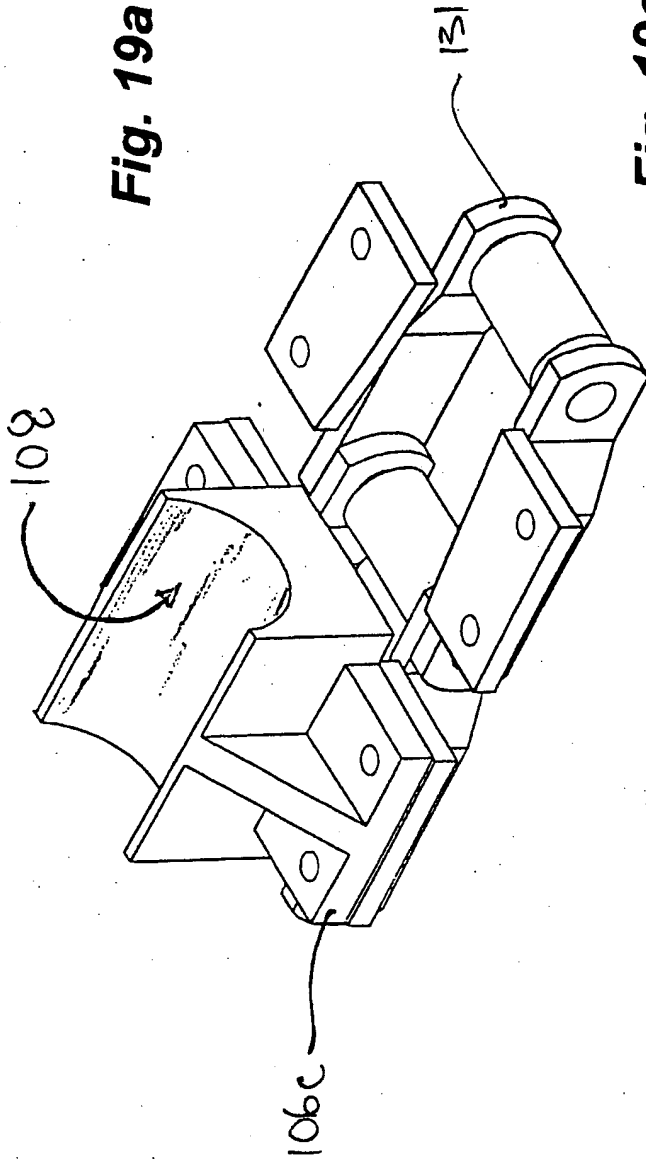


Fig. 19c

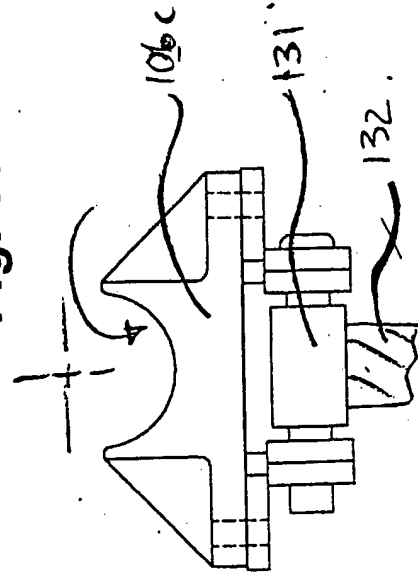
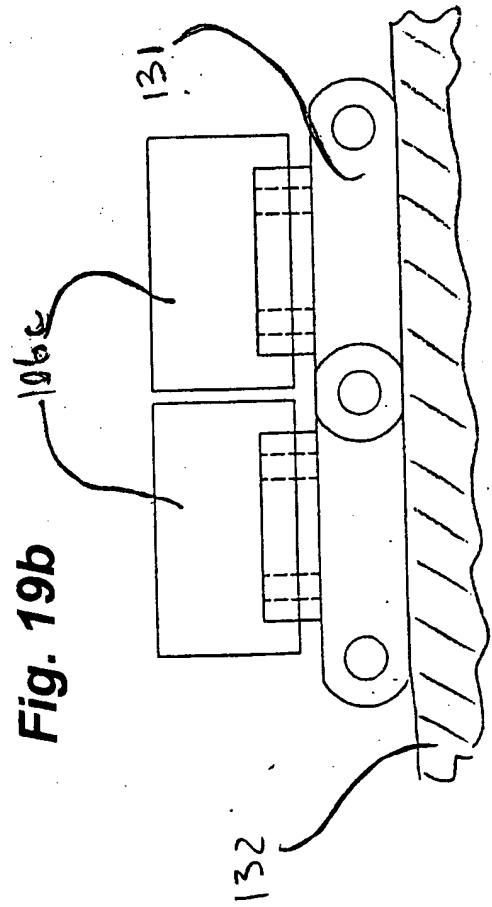
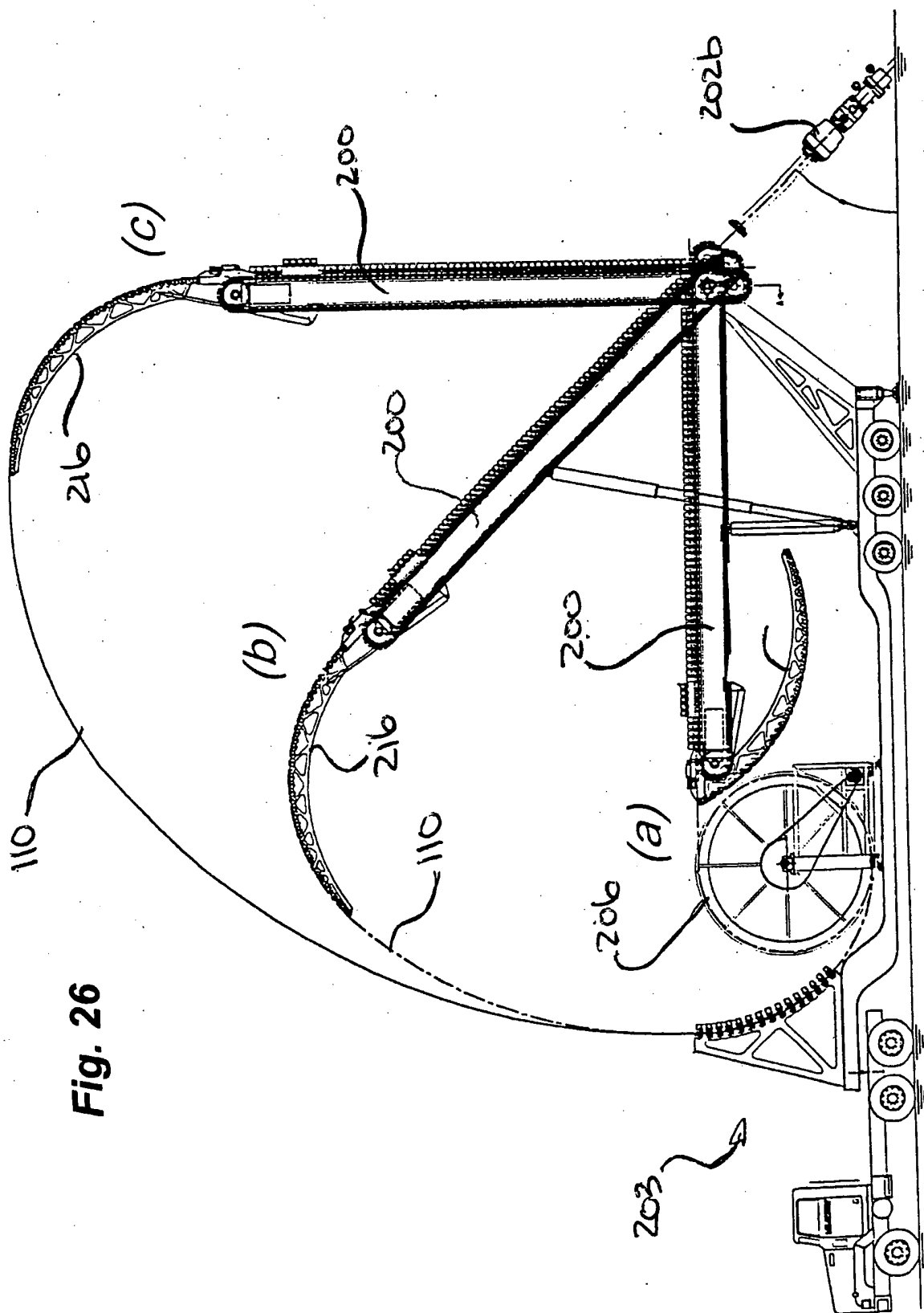


Fig. 19b





**Fig. 26**

Fig. 27

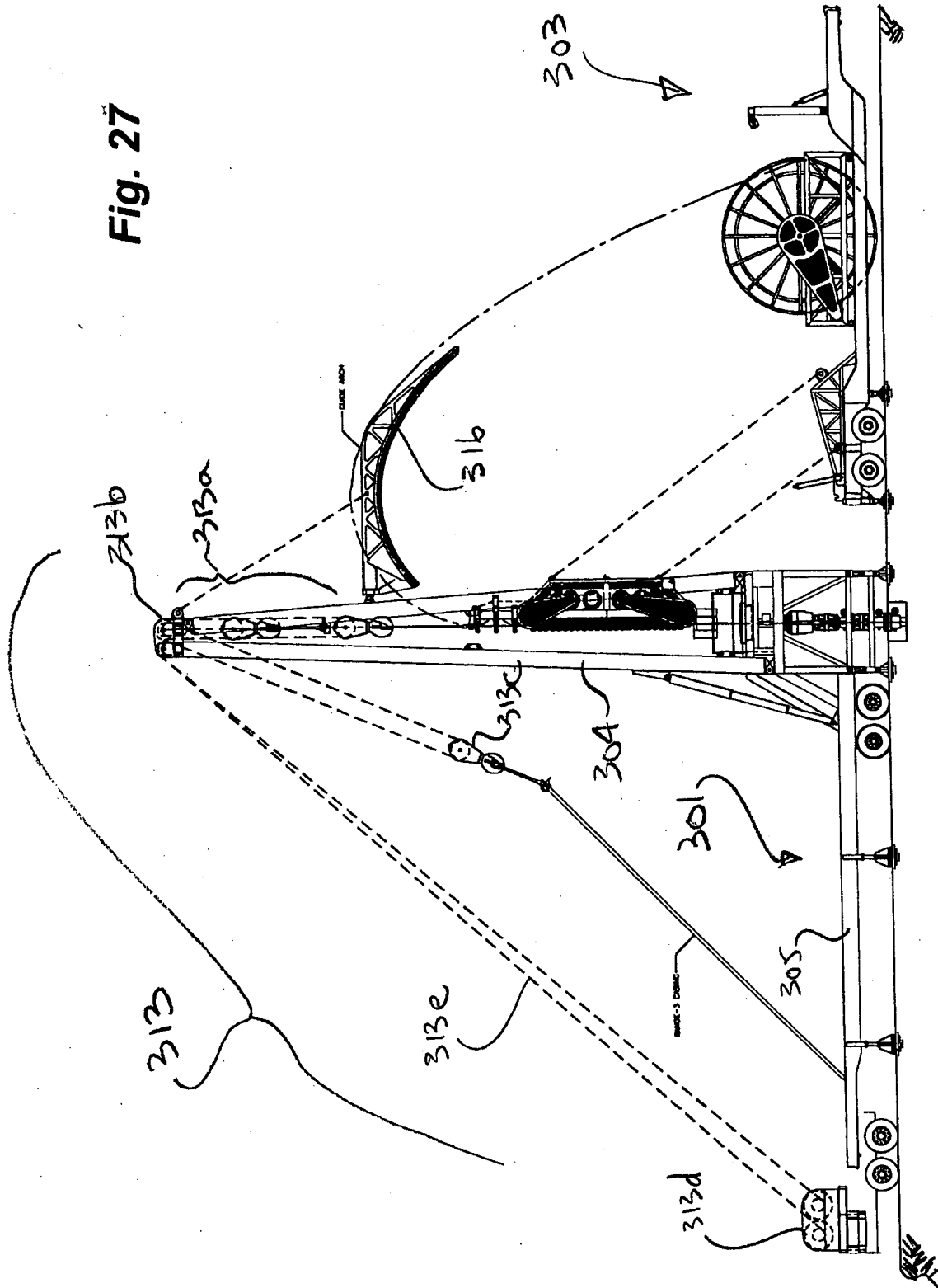


Fig. 28

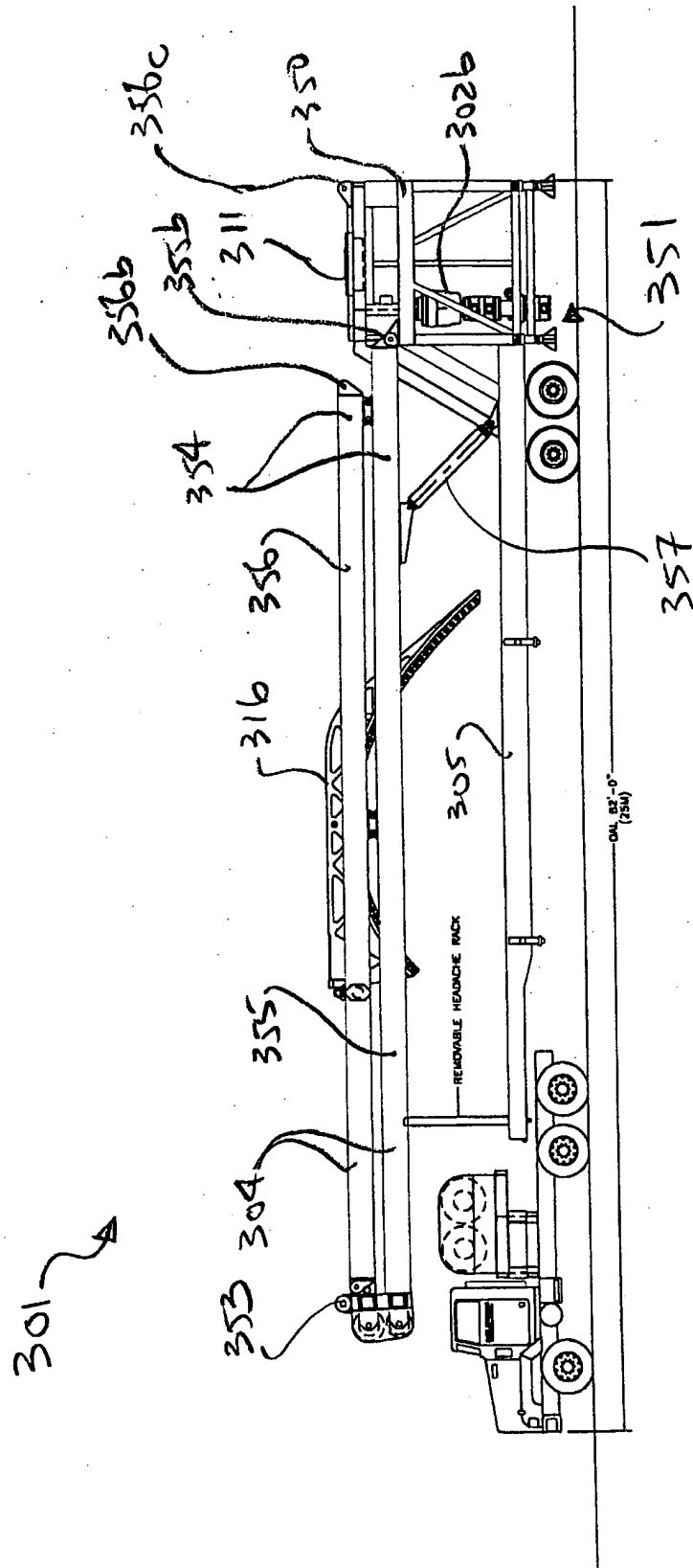
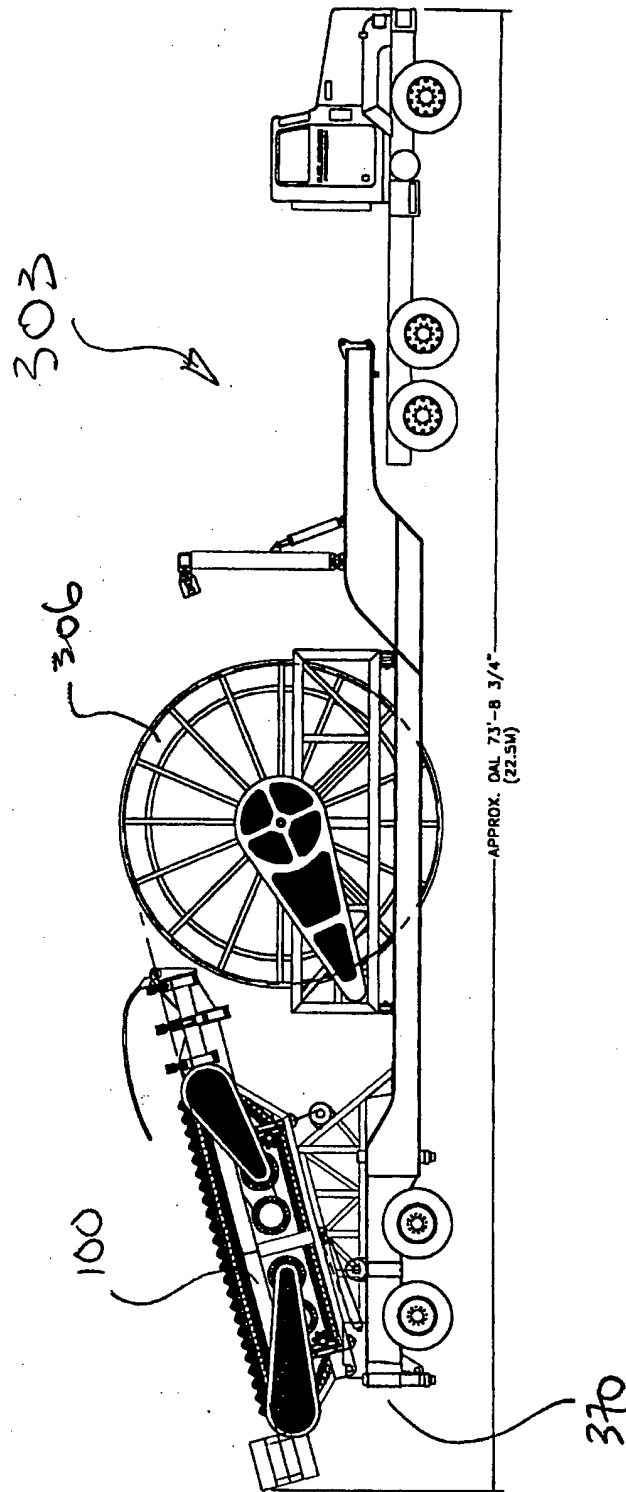
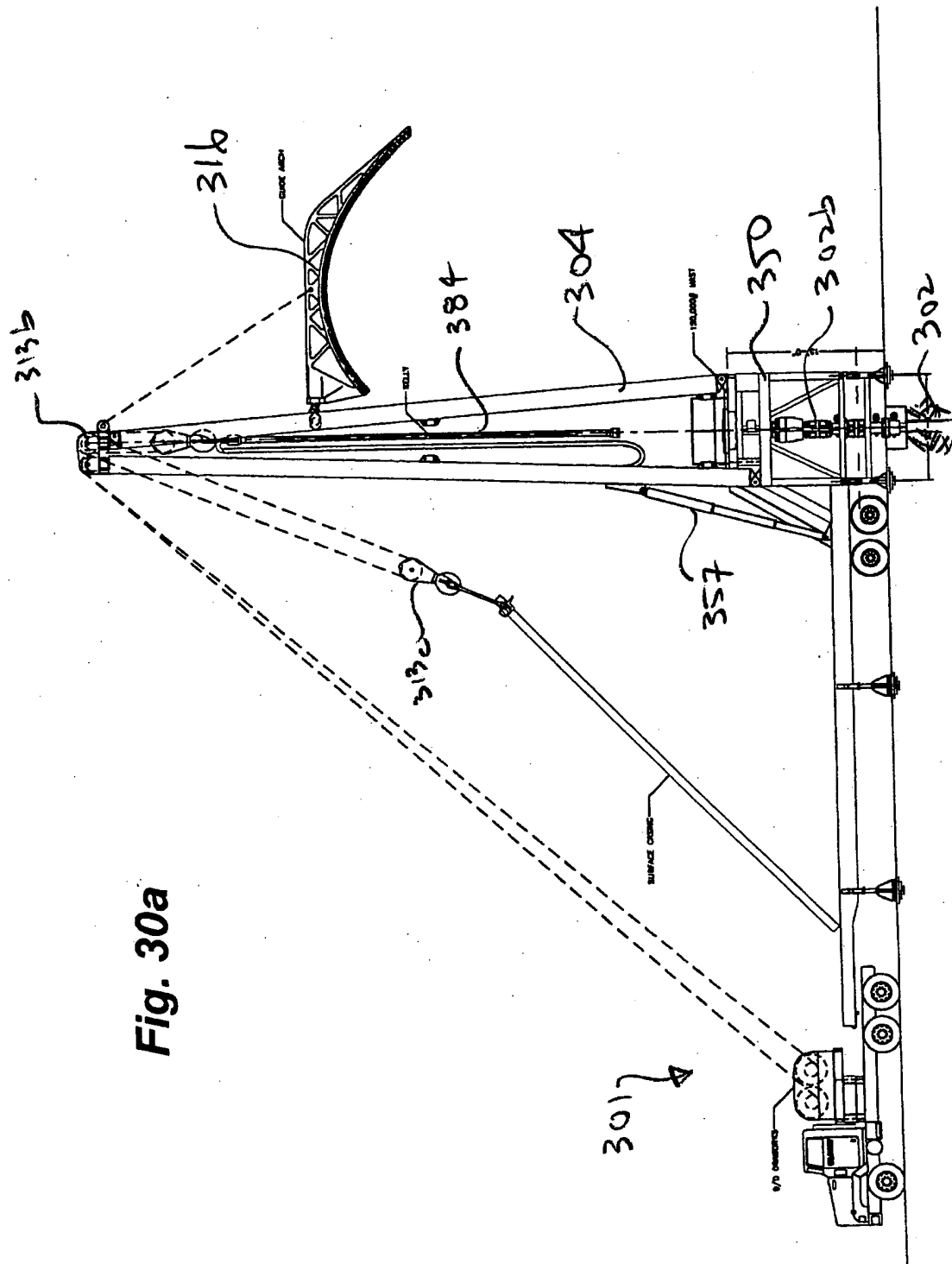
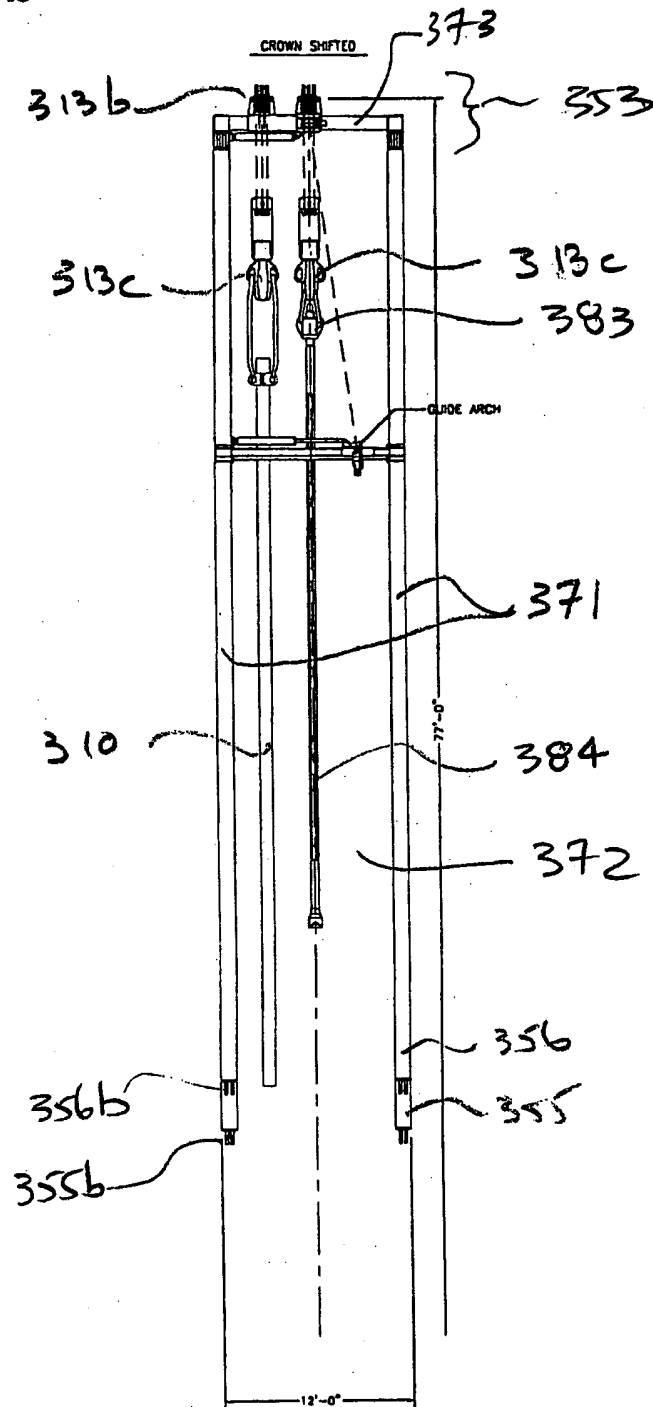
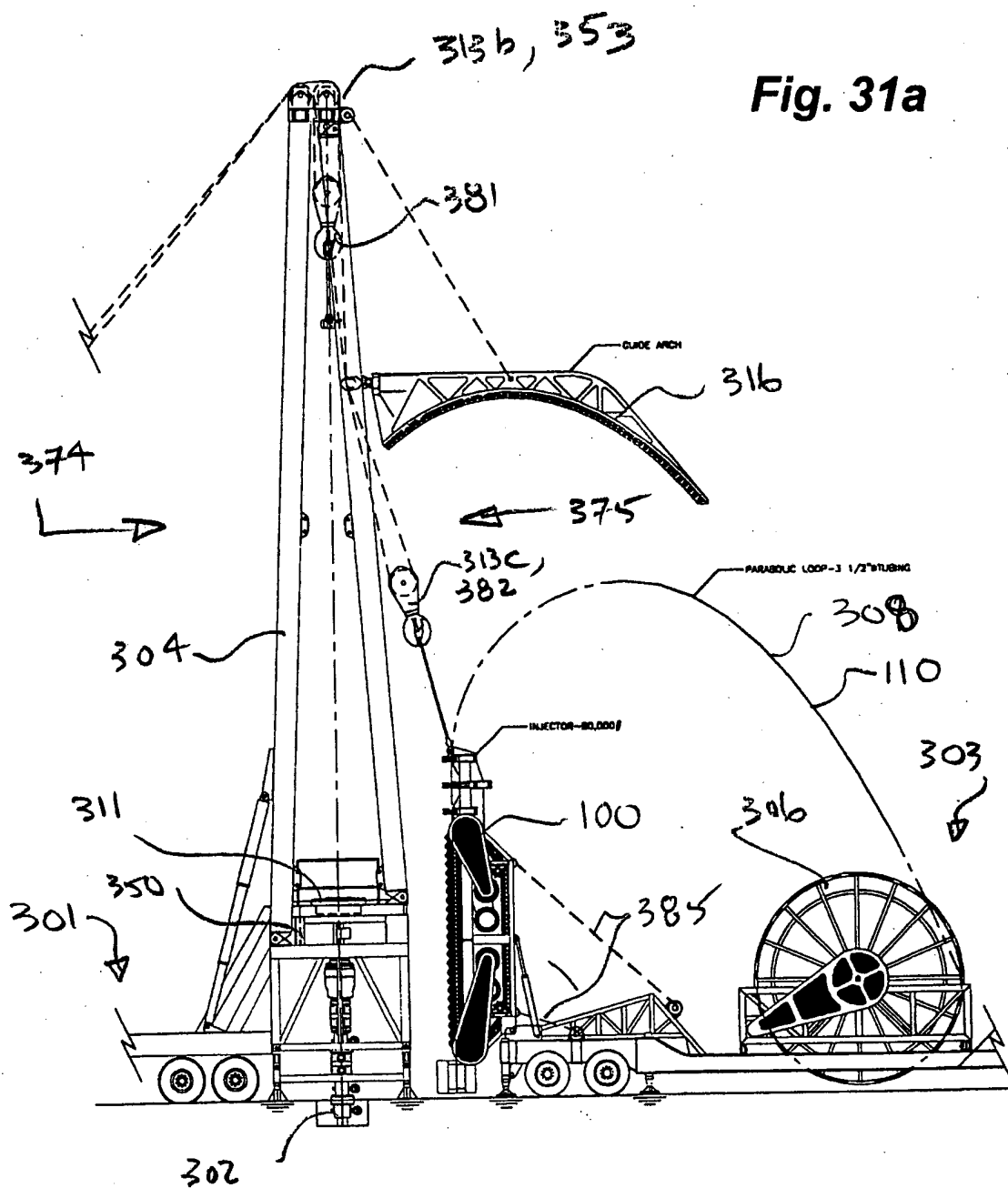


Fig. 29

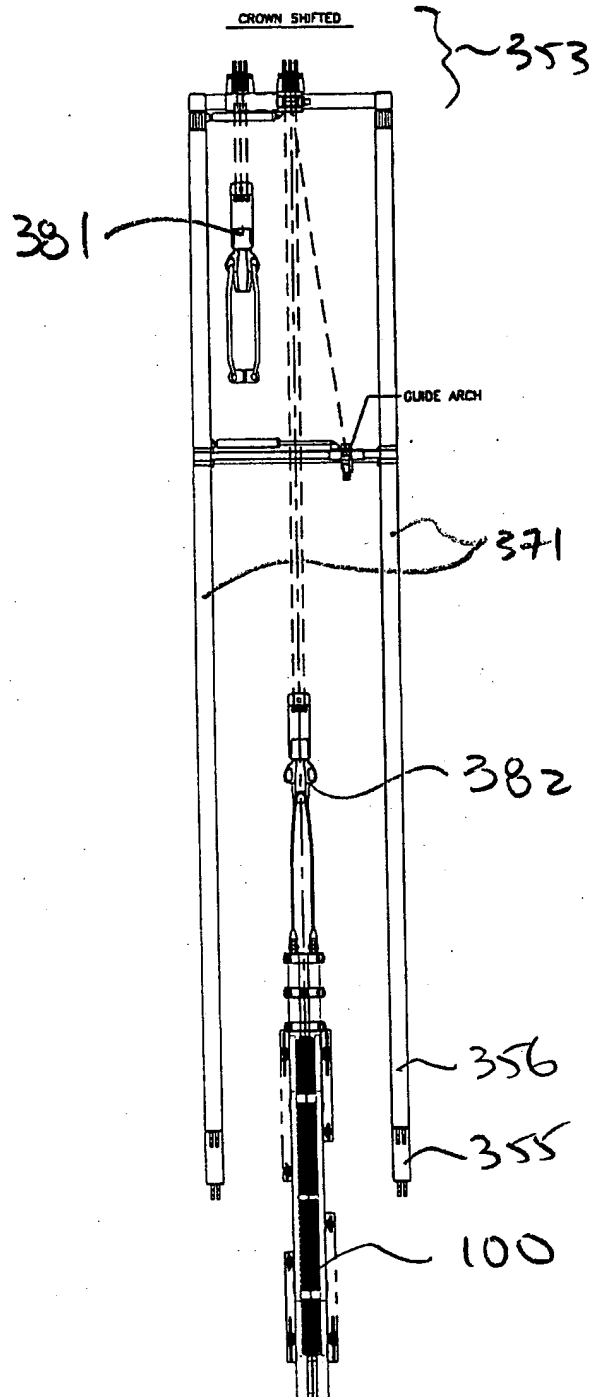


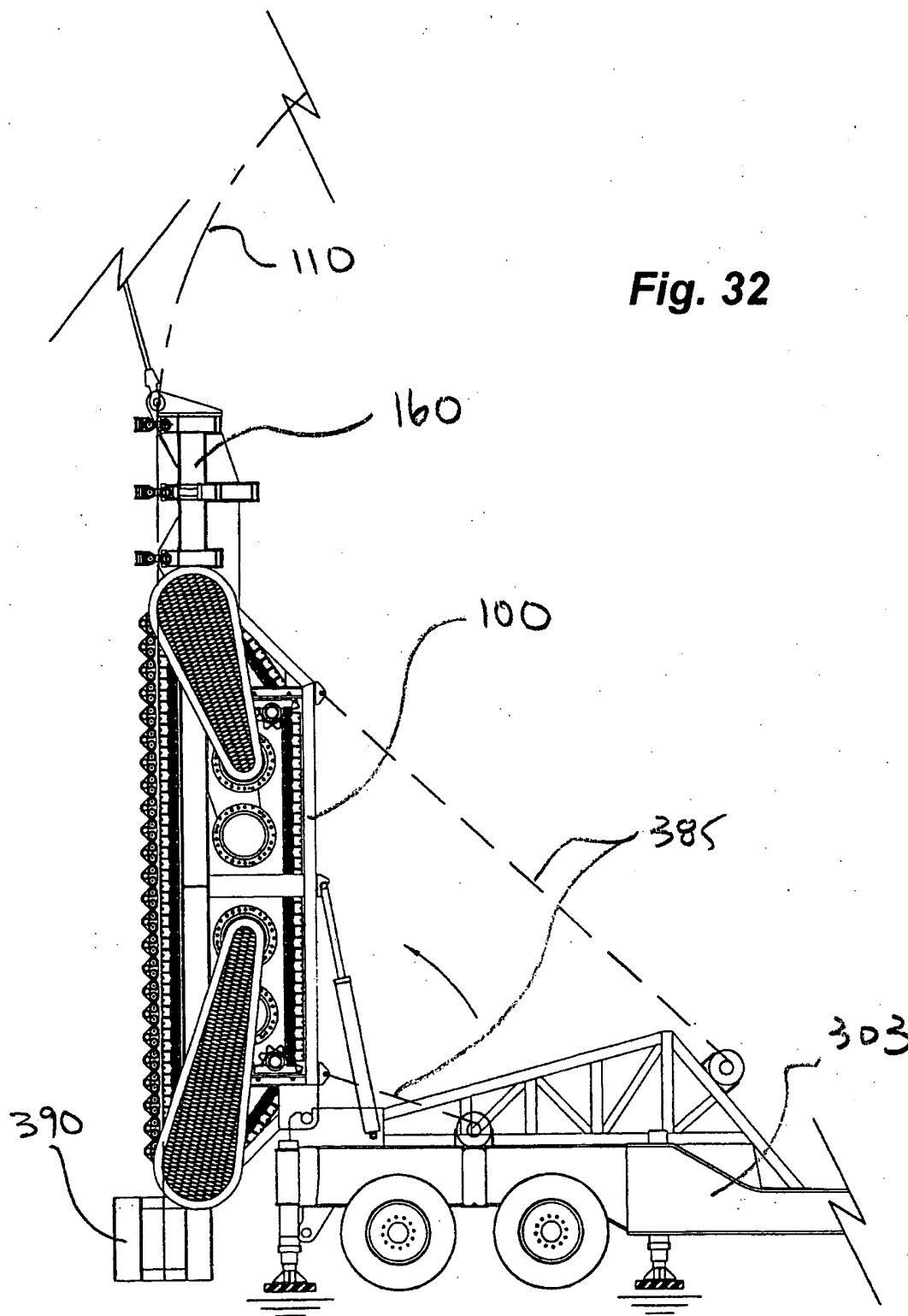


**Fig. 30b**

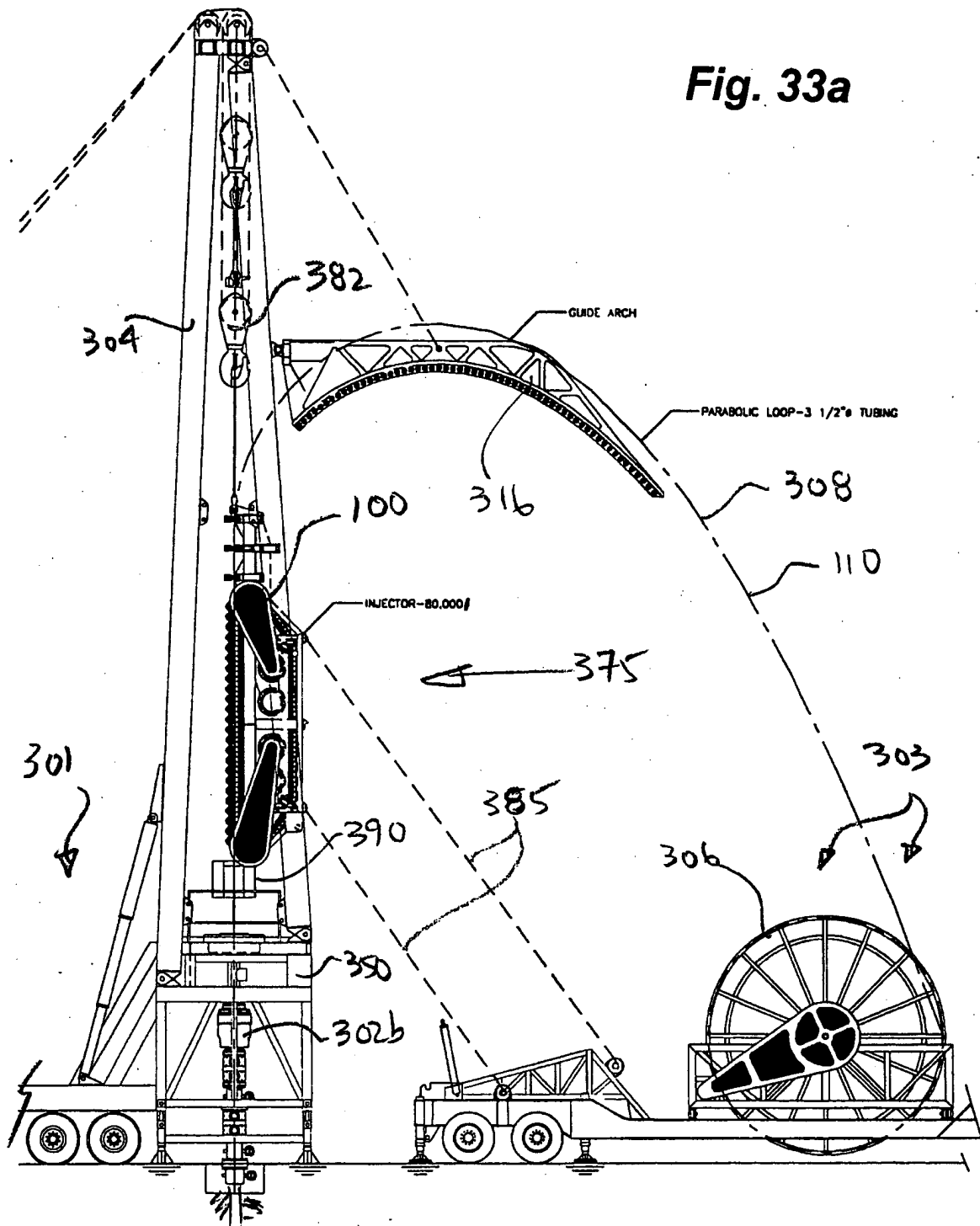


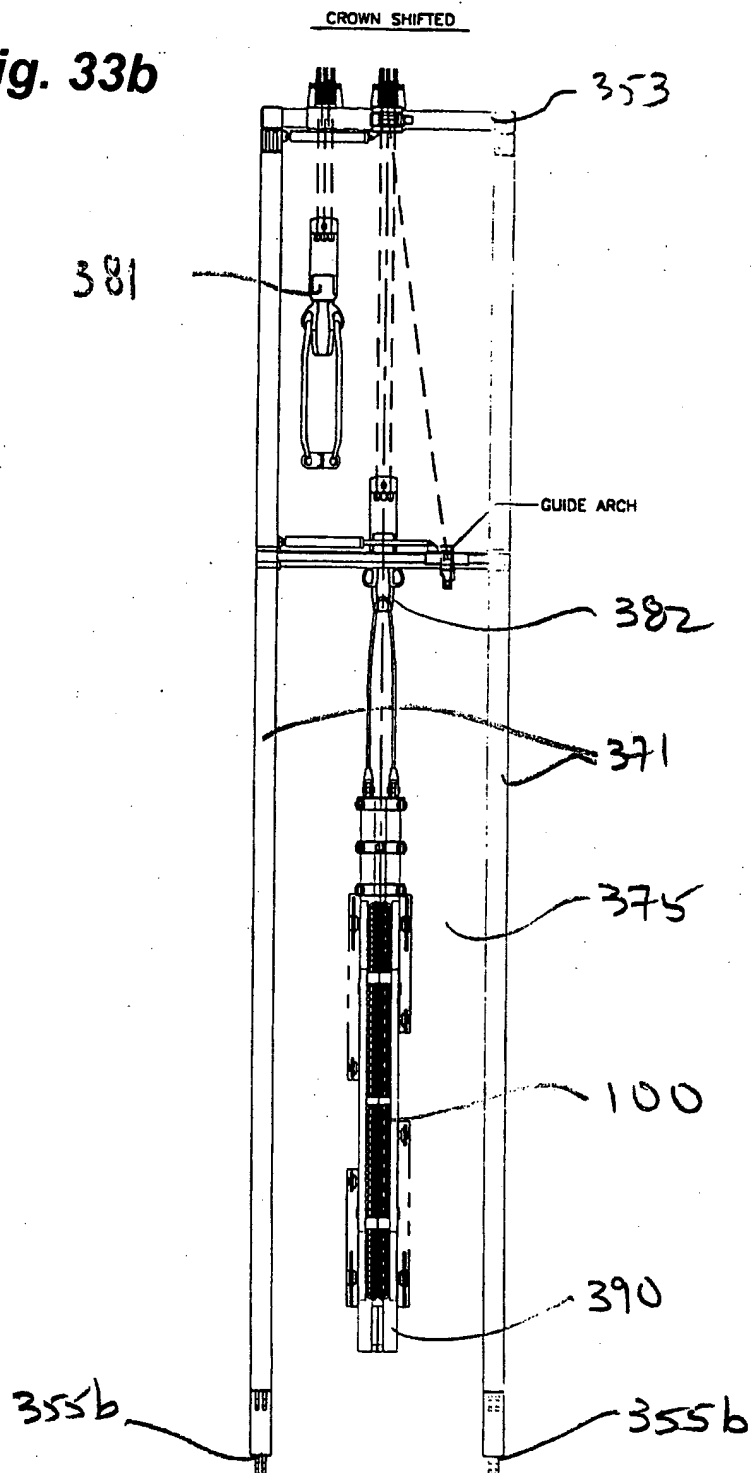


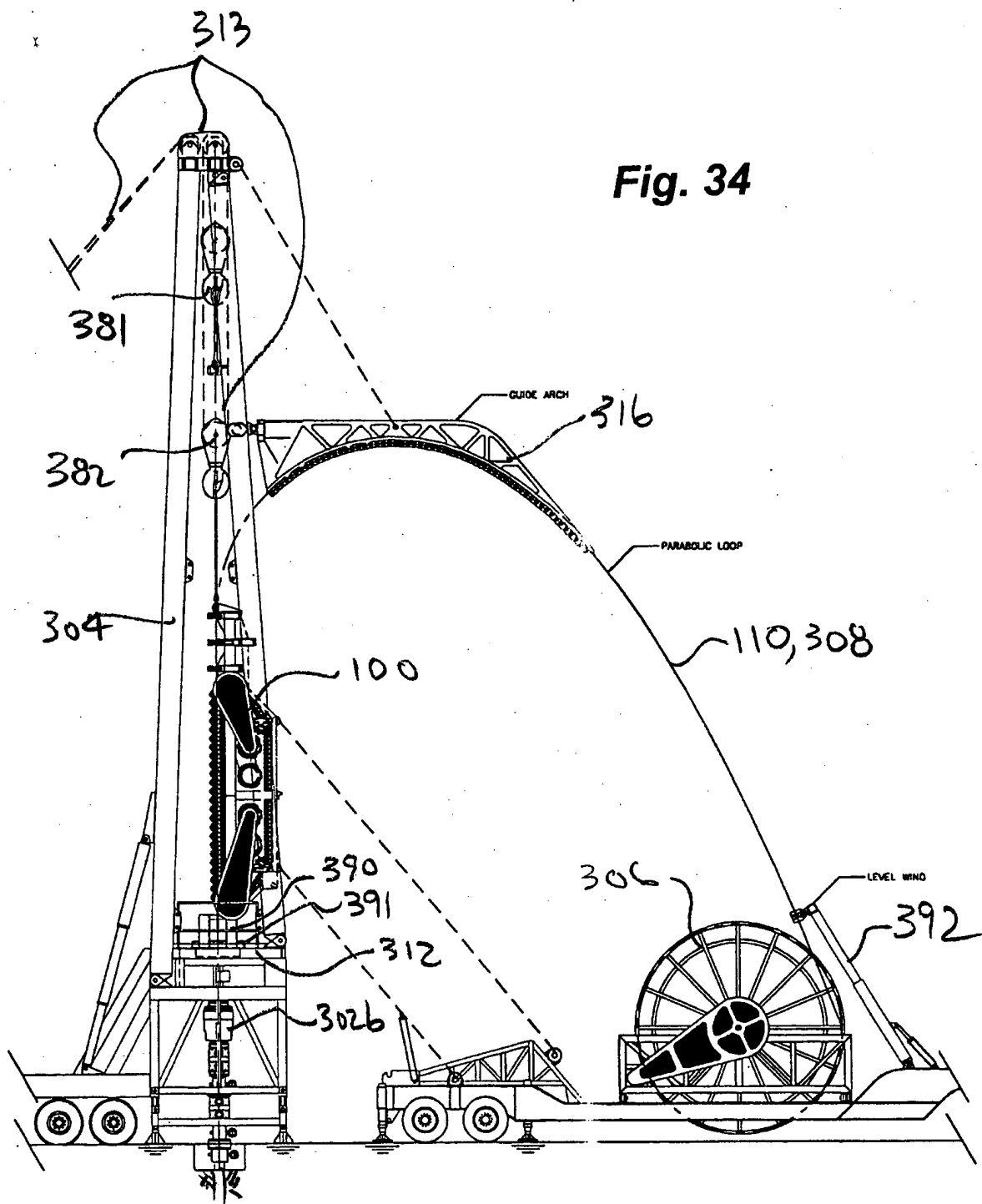
**Fig. 31b**

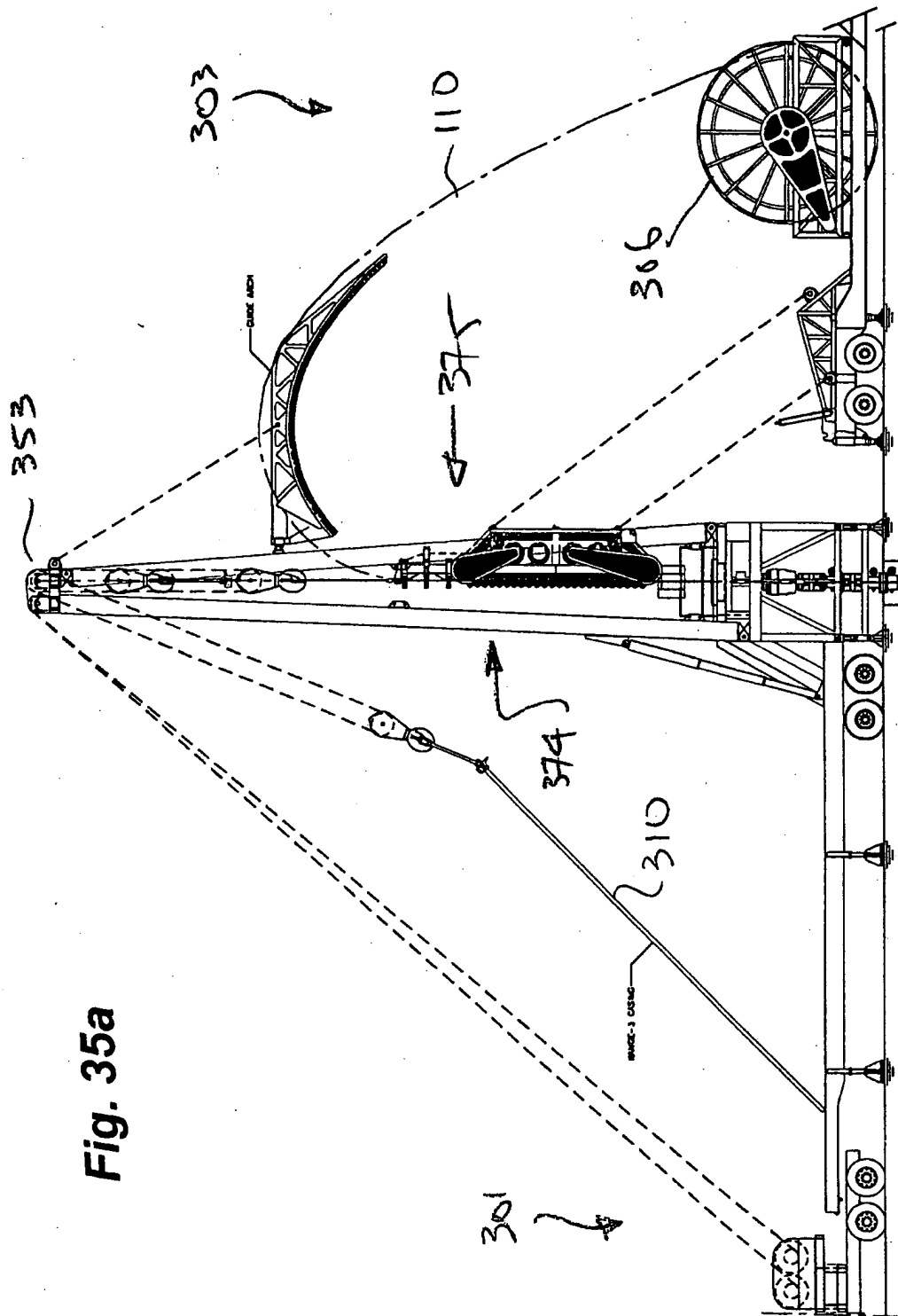


**Fig. 33a**



**Fig. 33b**





**Fig. 35a**

CROWN SHIFTED

**Fig. 35b**

